NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Washington, D.C. 20594

May 17, 2005

Aircraft Performance

Group Chairman's Aircraft Performance Study

A. ACCIDENT

Location:	Jefferson City, Missouri
Date:	October 14, 2004
Time:	1015 CDT
Aircraft:	N8396A, Flagship 3701, Pinnacle Airlines CL-600
NTSB Number:	DCA05MA003

B. GROUP

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C. SUMMARY

On October 14, 2004, at 10:13 pm central daylight time, a Bombardier Canadair Regional Jet (CRJ-200), N8396A, operated by Pinnacle Airlines and doing business as Northwest Airlink Airlines, crashed into a residential area in Jefferson City, Missouri, after declaring an emergency due to engine problems. The airplane was destroyed. The only occupants on board the airplane were the two pilots, and both were killed. There were no injuries on the ground. The non-revenue positioning flight departed from Little Rock, Arkansas, and was en route to Minneapolis, Minnesota before declaring the emergency.

Performance Group members arrived on scene the next day after the accident and commenced on scene documentation of the accident site, ground scars, tree strikes, and evaluation of the available radar data. Factual information gathered is contained in the Group Chairman's Aircraft Performance Wreckage Site Factual Report. Flight Data Recorder (FDR), Cockpit Voice Recorder (CVR), Federal Aviation Administration (FAA) radar data, weather data, and Air Traffic Control (ATC) communication data were used to develop the time history of the accident aircraft motion described in this report. Performance parameters for several portions of the flight are presented in this report. Composite plots will graphically show the location and orientation of the airplane when key events occurred

D. DETAILS OF INVESTIGATION

1. Accident Location

The accident aircraft debris was found scattered in and around the main wreckage resting location. The impact location of the nose was determined by a Global Positioning Satellite (GPS) receiver. The front edge (along the direction of travel) of the ground scar caused by the nose of the aircraft determined to be 38° 32.945' N, 92° 8.609' W, at an elevation of 740 feet mean sea level (msl). For details of information obtained from the wreckage site, see the Aircraft Performance Wreckage Site Factual Report.

2. Radar Data

The Air Route Surveillance Radar (ARSR) range and azimuth transponder secondary radar data for the accident flight was provided by the FAA. The ARSR data is obtained at a frequency of once every 12 seconds. The format supplied by the FAA contains time in hours, minutes, seconds, range from the radar site in nautical miles (NM), azimuth in ACP's (4096 ACP's = 360°), uncorrected (pressure) altitude, and beacon code. The range-azimuth-altitude format for each data set was converted to x-y-altitude format relative to the respective radar antenna using the magnetic variation for the radar site. In this converted x-y coordinate system, x represents true east and y is true north in nautical miles from the radar antenna. In the portion of the flight from final portion of the ascent to the accident site, radar coverage was obtained from the Crocker FAA long range antenna.

Radar data for the final portion of the ascent to 41,000 feet, and the subsequent descent is plotted on a map of the region in figure 2-1. Figure 2-3 shows data closer to the ground impact site. In this plot, the radar altitude is adjusted for the local altimeter setting of 29.63 inches Hg at Jefferson City airport (JEF) after the airplane descends below 18,000 feet. Figure 2-3 shows the radar altitude data. Plotted in figure 2-4 is the east-north distance relative to the Crocker ARSR antenna in with selected ATC communications during the final portions of the descent. The final radar return was about 0.58 n.m. southeast of the crash site at 930 feet-msl altitude (1200 feet pressure altitude uncorrected). Tabulated radar data, showing time, range, and azimuth from the Crocker antennae, uncorrected altitude, latitude and longitude is given in Attachment 2-1.

Figure 2-1 – Radar Ground Track

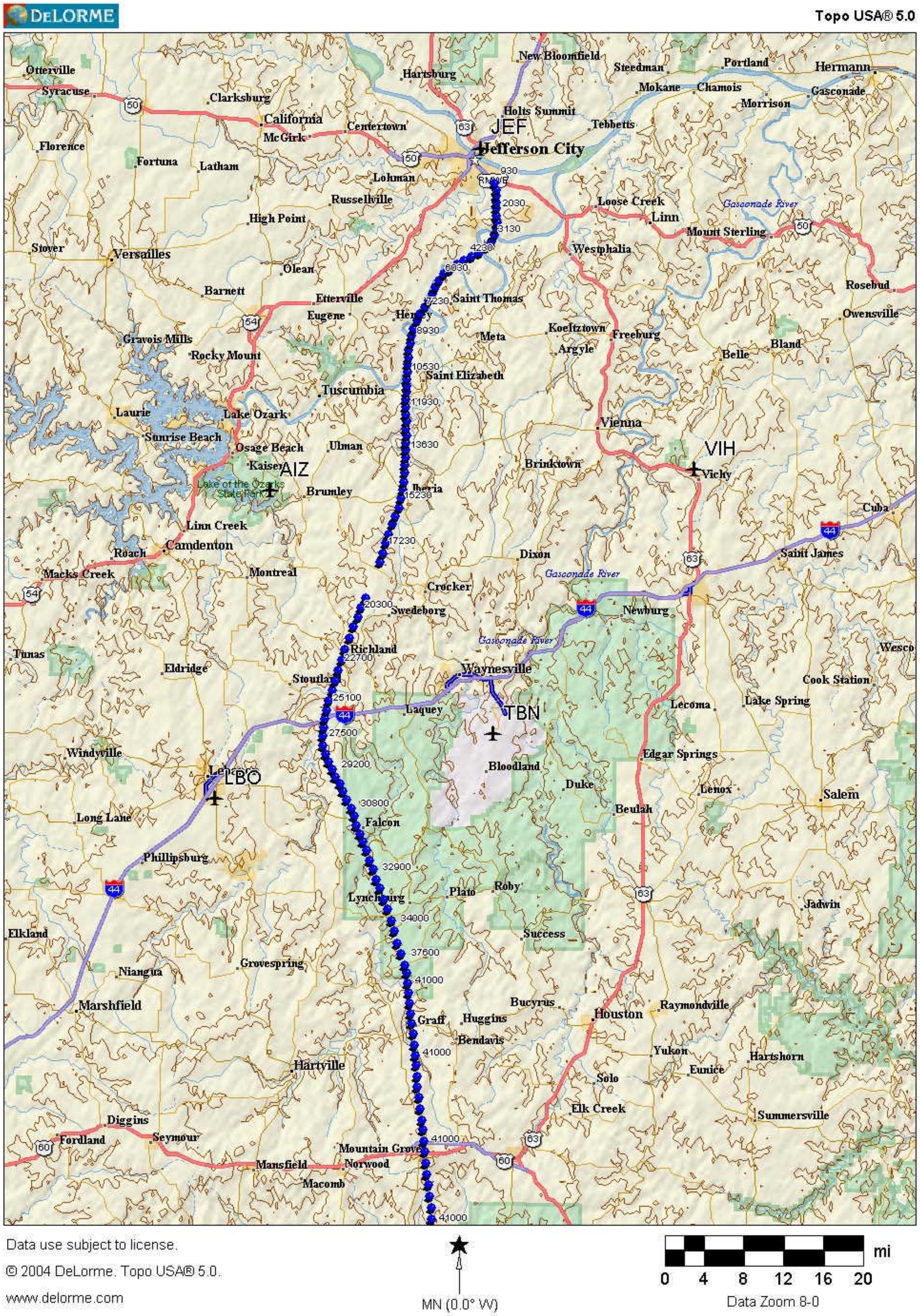
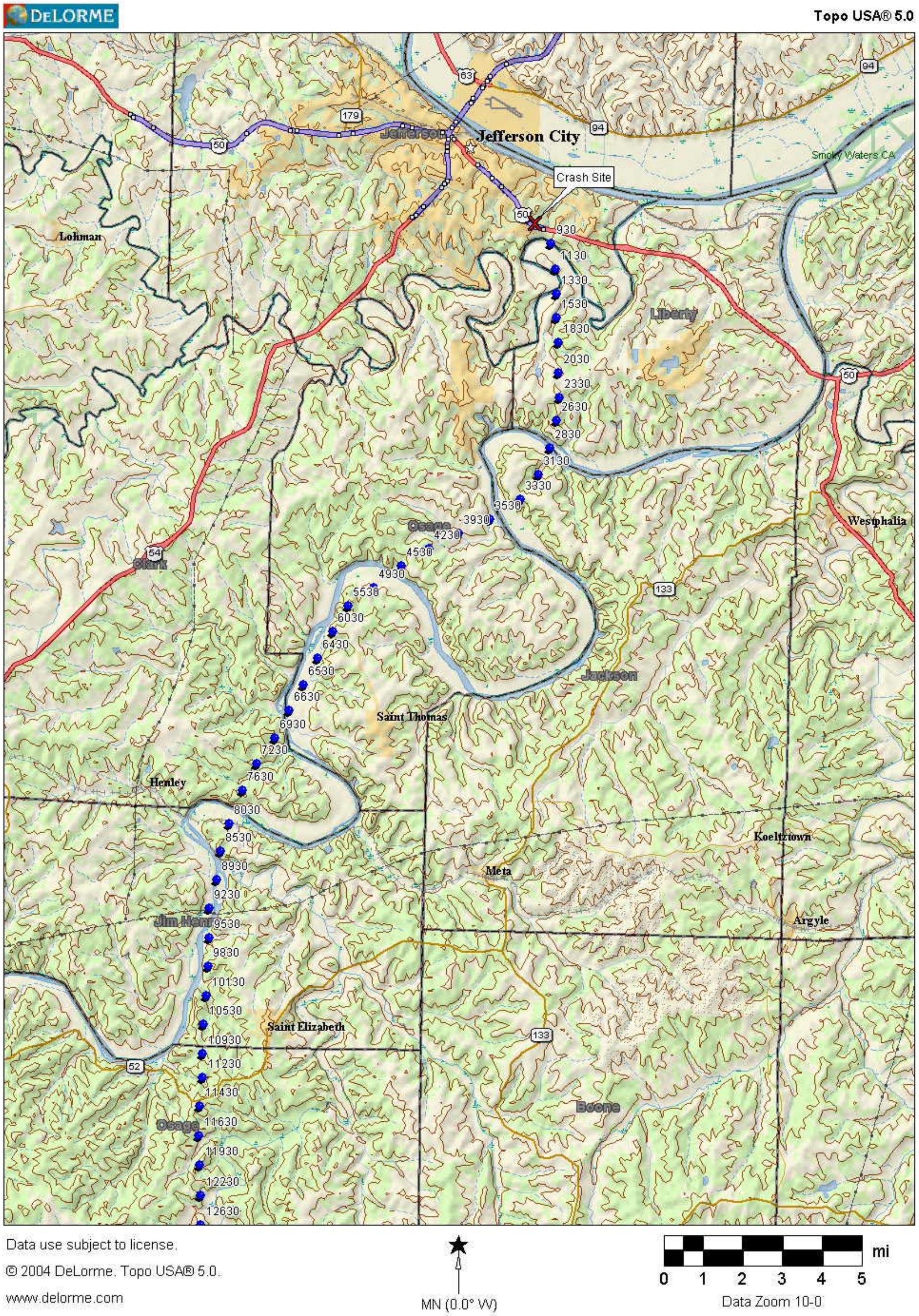


Figure 2-2 – Radar Ground Track



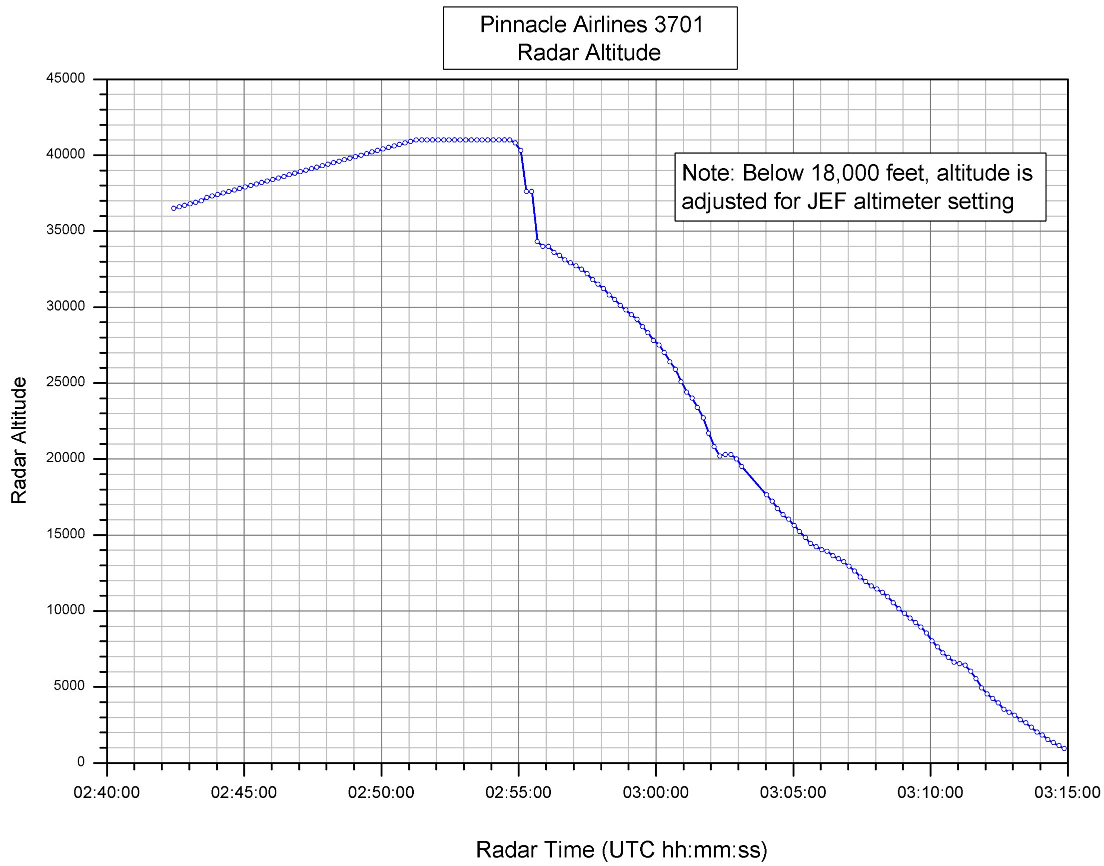


Figure 2-3 – Radar Altitude

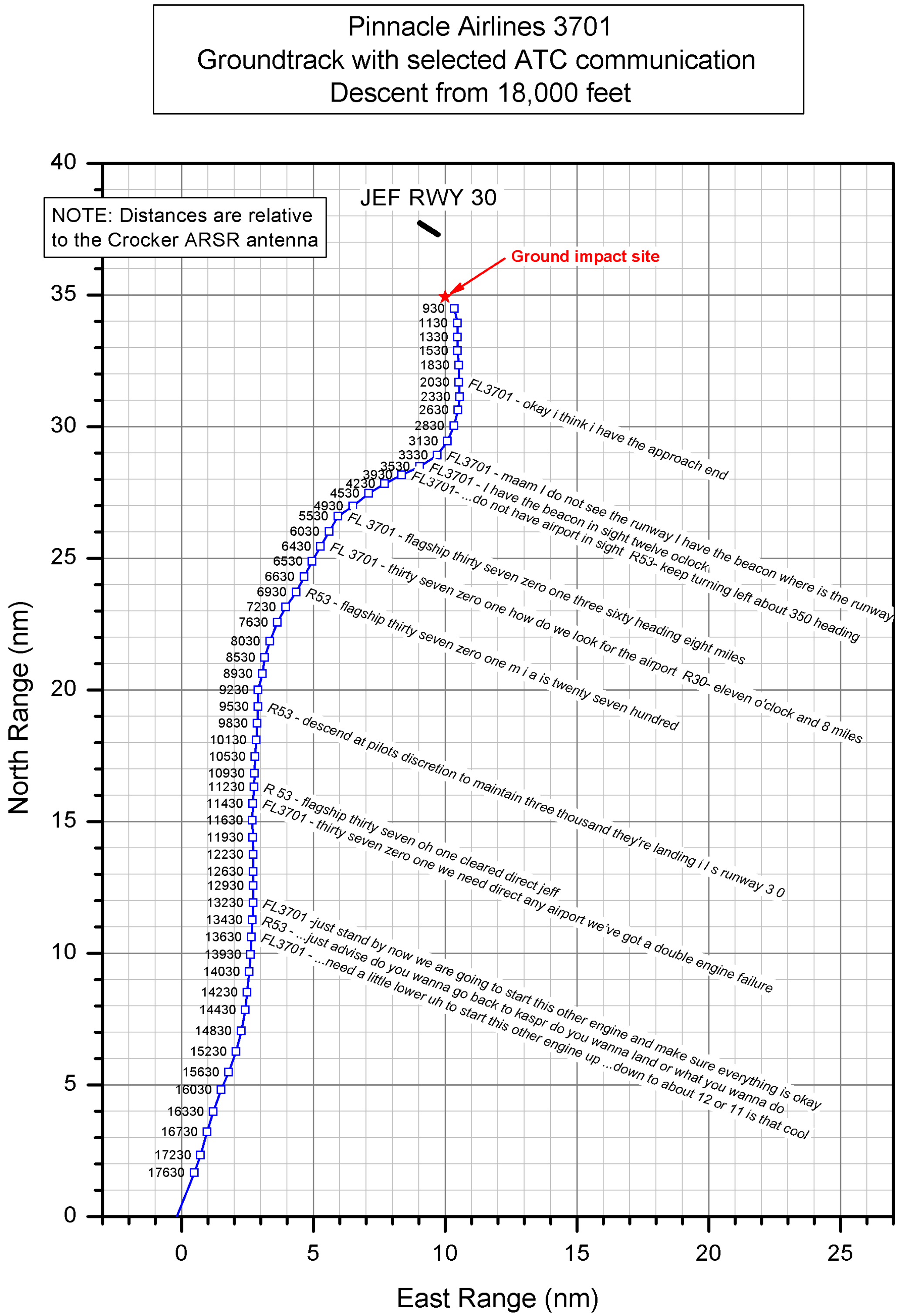


Figure 2-4 – Radar Ground Track

3. Time of day correlation

A time correlation was made between the ARSR radar data, FDR data, CVR transcript data, and Air Traffic Control (ATC) radio transmission transcript data. Times indicated with the ARSR radar data were used as the reference time, and FDR, CVR, and ATC clocks were adjusted accordingly. Times given in this report are in 24-hour format, in the form HH:MM:SS UTC Time. The FDR and CVR record information relative to an elapsed time in seconds, and are assigned a time of day correlation using the technique outlined below.

FDR/CVR Time Correlation

To correlate the elapsed time recorded on the FDR with the elapsed time recorded on the CVR, a comparison of the microphone keying on/off times from the FDR data was made with the start/stop times of the radio transmissions recorded on the CVR. The FDR records at one-second intervals whether the aircraft radio microphone is keyed "on" or "off". Initially, all the microphone keyings are used to get a rough correlation of the FDR and CVR elapsed times. However, since the microphone keying is recorded on the FDR only once per second, the FDR is a less precise determination since the FDR may record a microphone keying (or end of keying) up to 0.99 seconds after the event actually occurred. The CVR recording provides a much more precise reference time for each radio transmission in terms of the CVR elapsed time, typically to within 0.1 second. For details of the FDR/CVR time correlation see the FDR group Chairman's Factual Report of Investigation.

Once the FDR and CVR elapsed times were correlated with each other, the elapsed times were correlated to a time of day clock. A comparison of the radar uncorrected altitude versus local time and FDR pressure altitude versus elapsed time was used to correlate the radar data time of day to the FDR data elapsed time. Since there was an interruption of power and corresponding loss of data, correlations were performed both prior to and after the loss of data.

Both FDR pressure altitude and ARSR uncorrected altitude are based on a sea level pressure of 29.92 "Hg. Additionally, the altitude data provided with the radar data has an accuracy of +/- 50 feet. By adjusting the DFDR elapsed time so that the DFDR altitude falls within the +/- 50 ft. uncertainty band of the ARSR Mode C altitude during time period of interest, the offset between DFDR time and radar time of day can be determined.

The comparison of the FDR altitude and radar altitudes yield correlations of

BEFORE LOSS OF POWER: 02:45:00Z = DFDR SFRN 181300.60
AFTER LOSS OFPOWER: 03:00:00Z = DFDR SFRN 182199.85

With these correlations applied to the FDR and CVR data, the ATC transcript provided an additional check of the correlation for the radio transmissions. Plots 3-1 and 3-2 shows FDR pressure altitude and ARSR radar altitude versus UTC time, using the time correlations given in this section. A representative plot for each correlation is shown, during times of altitude variation to show the efficacy of the correlations to fit within the error bands of the radar altitude data. Subsequent plots use these correlations to relate the FDR data to the time of day.

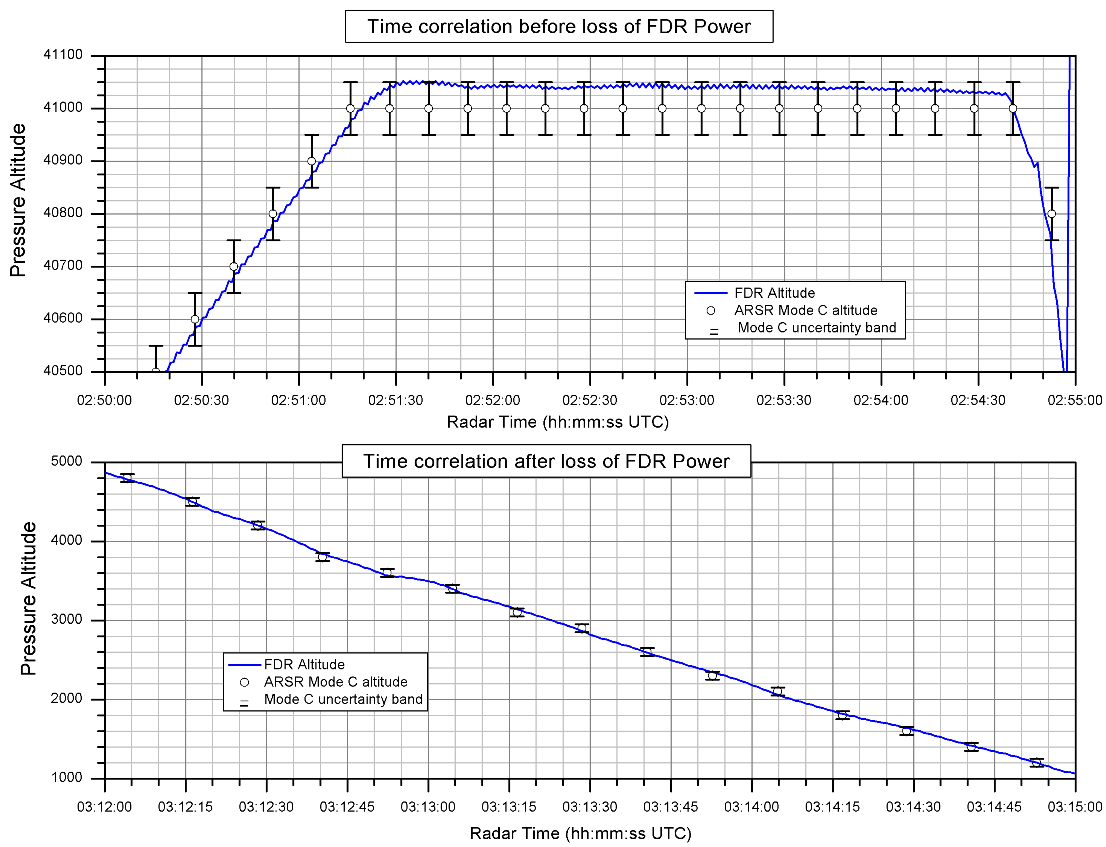


Figure 3-1 and 3-2 – Time of day correlation

4. Aircraft and Atmospheric conditions

Information from the Meteorology Group Chairman Factual Report indicates that the temperature conditions of the atmosphere were International Standard Atmosphere plus 9.4 degrees Celsius (ISA + 9.4). Additionally information from the Operations Group Chairman's' Factual Report indicated the weight at take-off was 39,372 pounds. Based on the fuel quantity recorded on the FDR in both the left and right fuel tanks, the aircraft weight at upset at 41,000 feet was 37,804 pounds. Center of gravity (c.g.) location was estimated by the Operations Group to be 21.6% of the mean aerodynamic chord (MAC).

5. Flight Path Description

Ascent

Examination of the FDR data showed portions of the ascent where sharp pitch up maneuvers occurred. Pitch up maneuvers were identified at three separate times between liftoff and the final level off altitude at 41,000 feet.

The accident aircraft was not equipped with a control force measuring system. By employing a simulation by Bombardier Aerospace, the Performance Group calculated the pitch control forces for various portions of the accident flight. A control force model was implemented based on the recorded stabilizer and elevator positions, with the sum of the system friction, centering forces, and the column force gradients. Pitch control forces were calculated during several portions of the ascent. Additionally, Mach number was calculated during the flight using the recorded computed airspeed and total air temperature.

Takeoff

Plots showing the altitude, airspeed, accelerations, and control inputs are shown in figures 5-1 and 5-2. Note the initial rotation occurs at 02:21:45, up to a pitch angle of about 6 degrees. Control force calculations showed that this column movement required 26 pounds of force. Four seconds later, a larger column deflection to 8 degrees[1] raised the pitch of the aircraft to 22 degrees, and generated close to 1.8 g's of vertical acceleration. Force calculations indicated that 34 pounds of pulling force was required during this maneuver. A single stick pusher discrete is recorded on the FDR, followed by a column deflection to full nose down and reduction of pitch angle.

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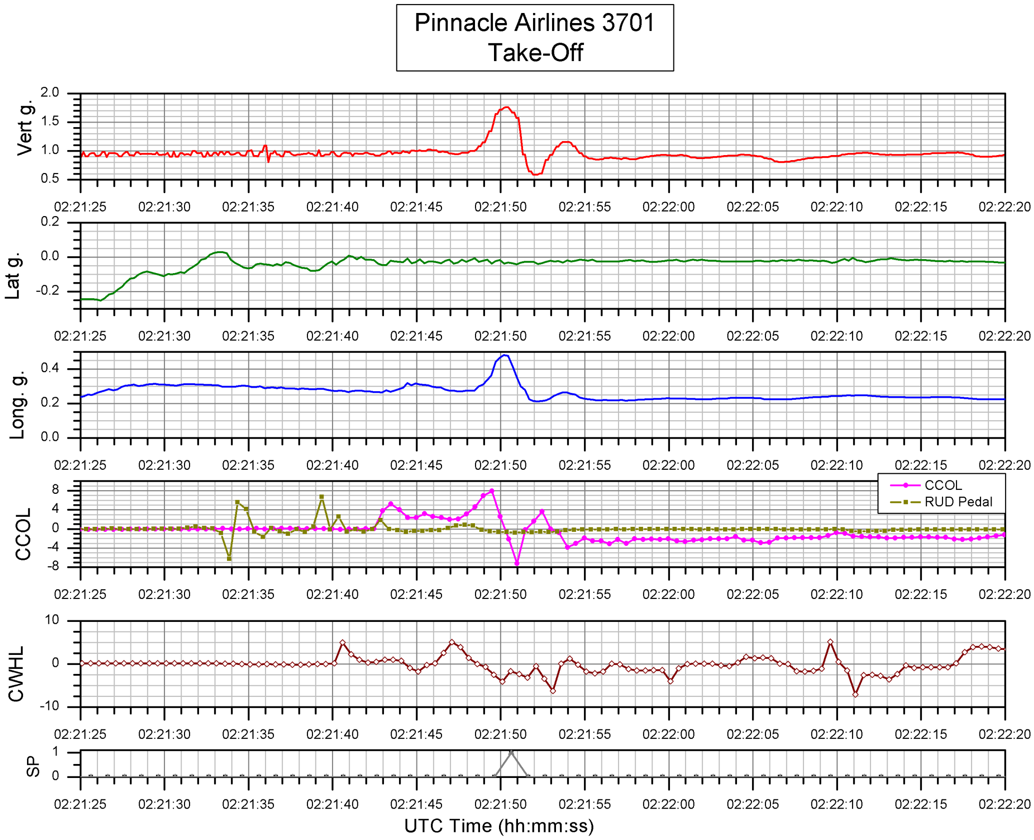
[1] Information from the Flight Data Recorder Group Chairman indicated that the range of motion for the pitch controls during the control check was -8.6 degrees (nose down) to 10.2 degrees (nose up).


Pinnacle Airlines 3701
Take-Off
Vert g.
Lat g.
Long. g.
CCOL
CCOL
RUD Pedal
CWHL
SP
02:21:25
02:21:30
02:21:35
02:21:40
02:21:45
02:21:50
02:21:55
02:22:00
02:22:05
02:22:10
02:22:15
02:22:20
UTC Time (hh:mm:ss)

<u>Figure 5-1</u>

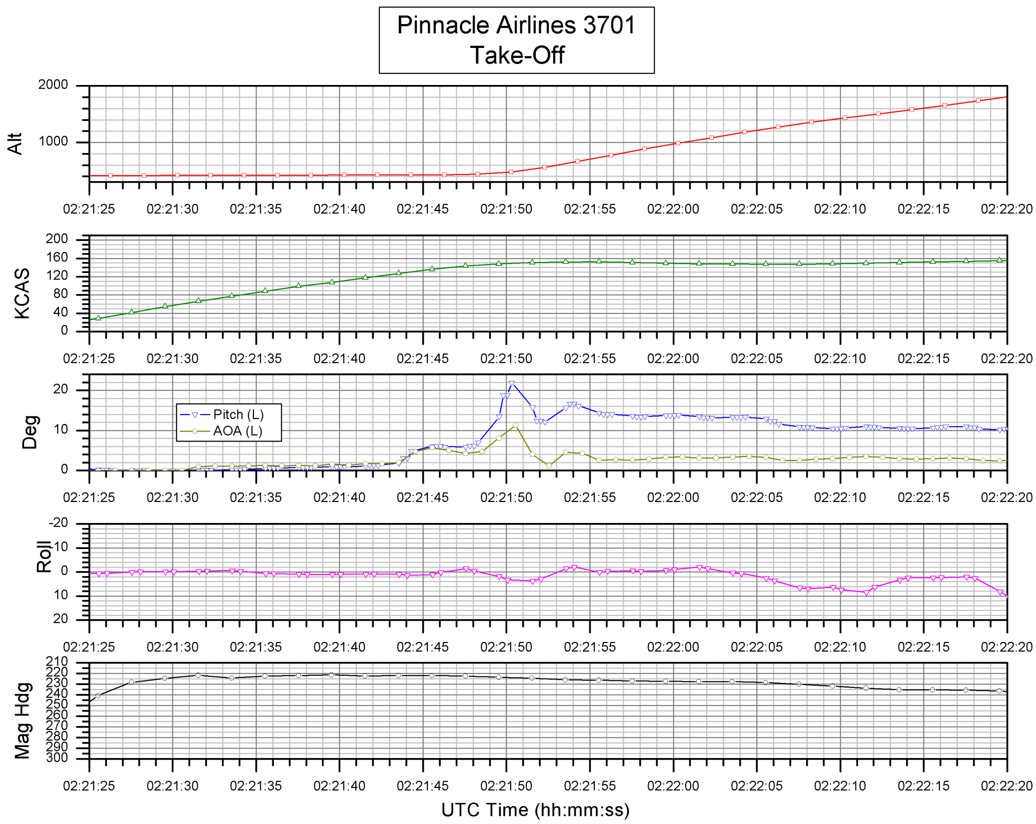


Figure 5-2

15,000 feet

Figures 5-3 and 5-4 show flight parameters while the airplane is at 15,000 feet. At approximately 02:27:17, while level at 15,000 feet, the autopilot is disconnected and a pull up in initiated with a column deflection. A calculated force of 30 pounds nose up is required as the column is deflected to 3.8 degrees. Over 2.3 g's of vertical acceleration is generated as the airplane pitches up to 17 degrees over the next several seconds. At 02:27:26, a nose down push is initiated, requiring a calculated 20-pound force in the nose down direction. During this push, the vertical acceleration drops to close to 0.3 g's. This is followed by another pull of about 26 pounds.

Approximately 70 seconds later, a rudder doublet is performed, consisting of a large rudder input to the left, then to the right. This generates close to 0.16 g's of lateral acceleration on the first deflection left, than 0.34 g's lateral acceleration to the right, than 0.18 g's back to the left. After these maneuvers, the autopilot is reconnected at 02:29:27 as the airplane ascends through 22,300 feet.

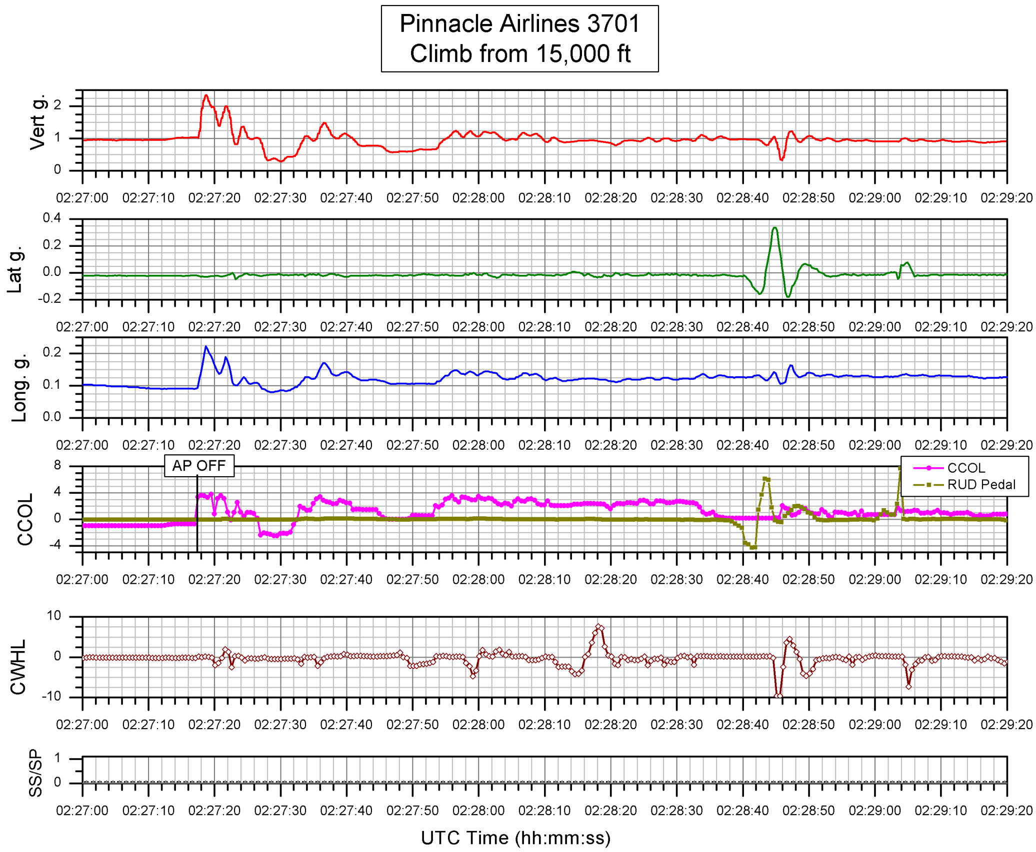


Figure 5-3

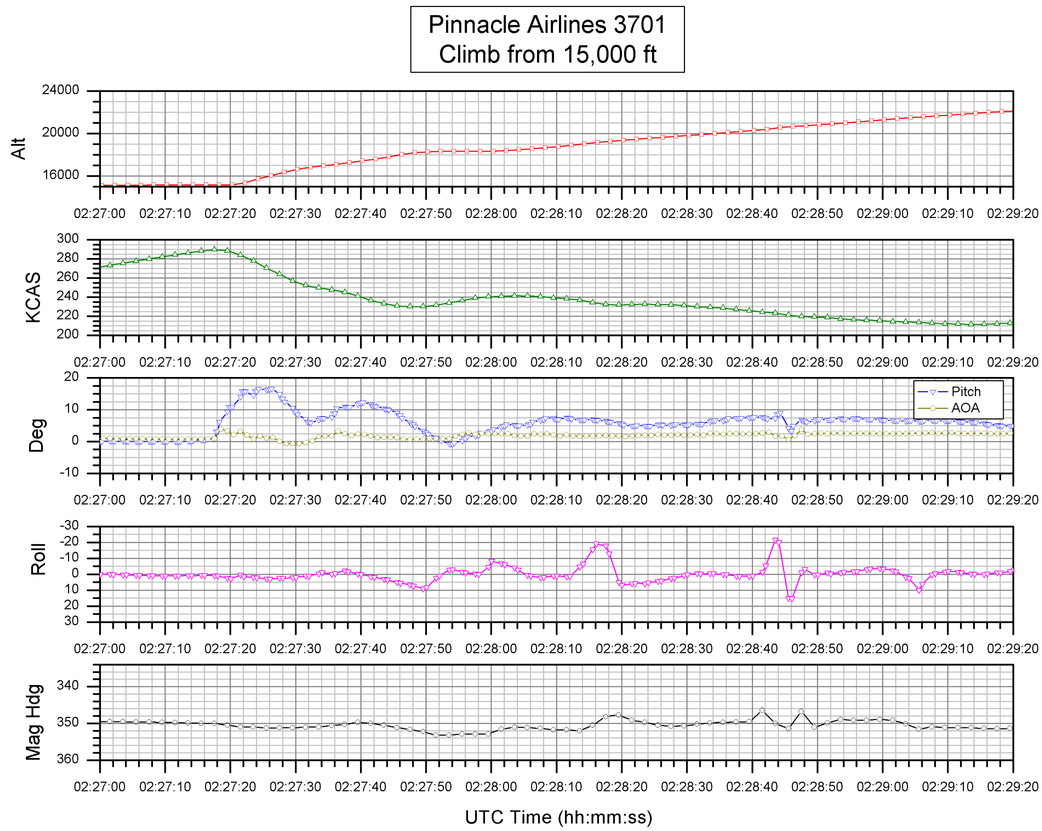


Figure 5-4

25,000 feet

While at 25,000 feet, a climb is initiated with the autopilot engaged and vertical speed selected at 600 feet/min. Flight parameters are shown in figure 5-5 and 5-6. With the autopilot engaged, the column is moved aft to 4 degrees airplane nose up by 02:32:40. This increases the pitch to over 10 degrees, and generates 1.87 g's vertical acceleration[2], and increased to the climb rate to over 5000 fpm for several seconds. At 02:32:46, the autopilot is disconnected and the column is pulled with a force of 34 pounds, increasing the pitch to close to 15 degrees. The column position remains between 3 and 4 degrees over the next 8 seconds. This column force is released, and another pulling force is gradually applied starting at 02:32:58, reaching a calculated peak of 44 pounds as the column moves to 5.3 degrees. The autopilot is then re-engaged at 02:33:10 with

[2] Information from Bombardier Aerospace indicates that the autopilot cannot command vertical g's greater than +/- 0.2 g's.

a target climb rate of 3000 ft/min, which is reduced to 1400 ft/ min, and then 1000 ft/min by 02:32:04.

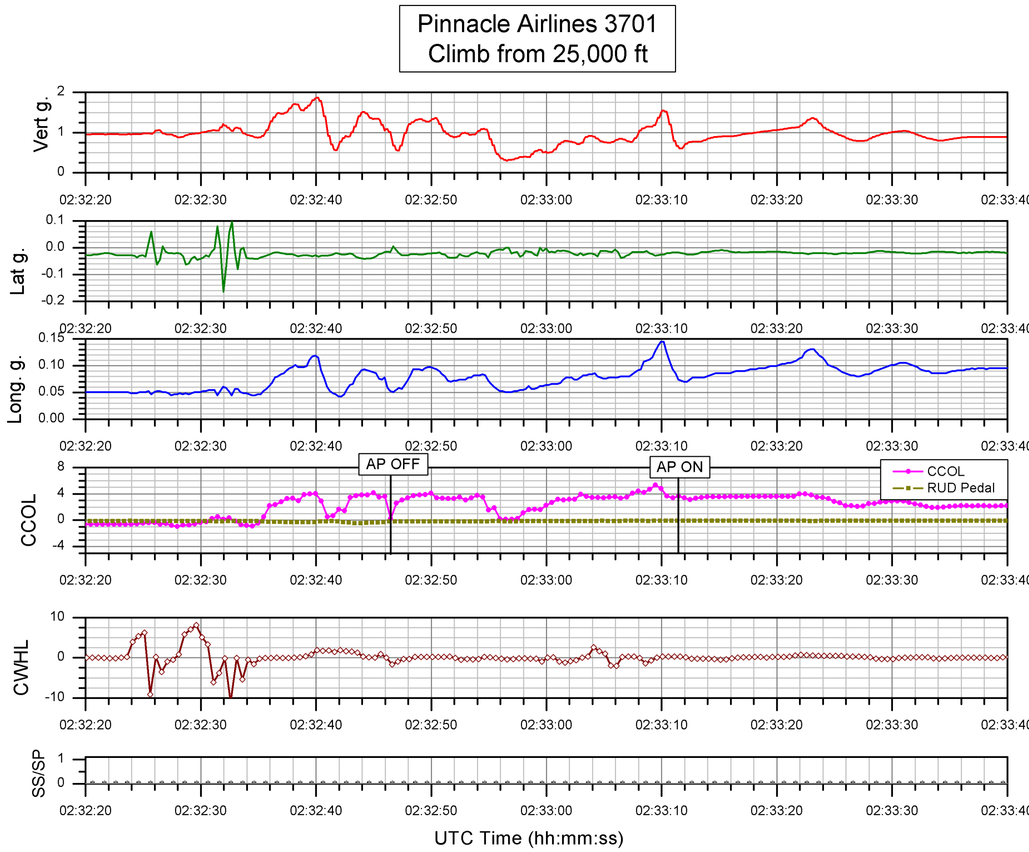


Figure 5-5

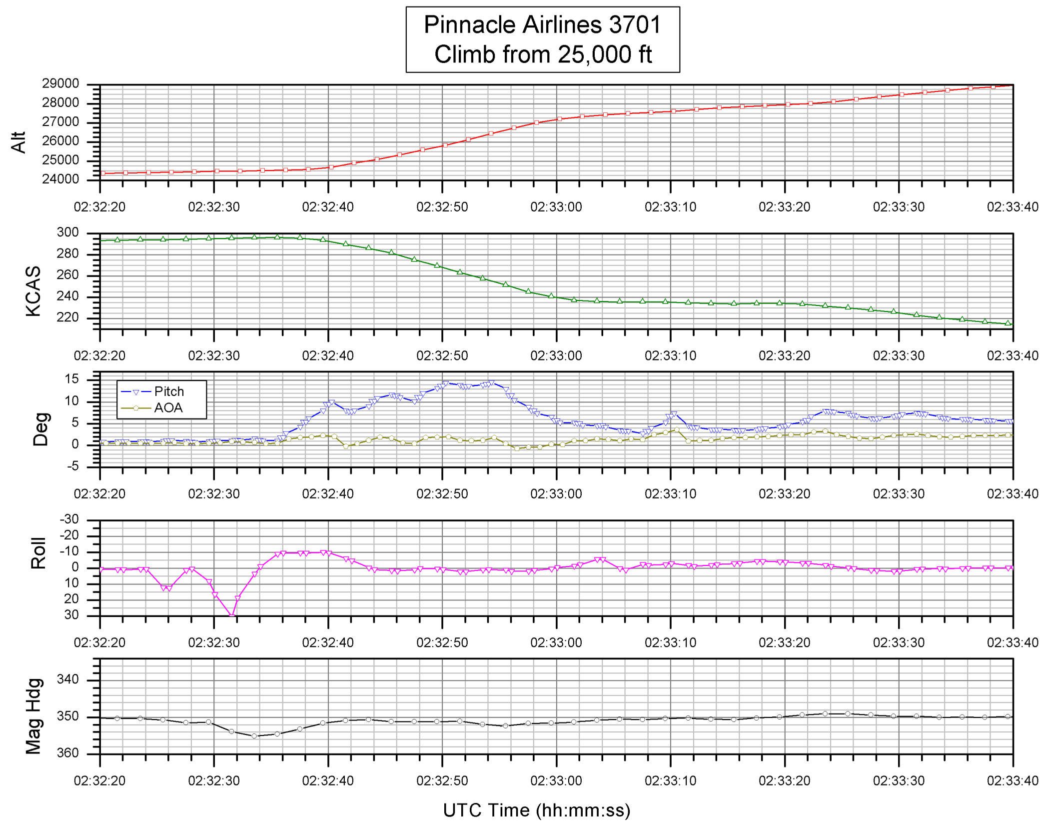


Figure 5-6

Bombardier Flight guidance for climb to 41,000 feet and altitude selection.

Bombardier Aerospace in their Flight Planning and Cruise Control Manual (CSP A-084) provides guidance for climb performance up to the climb ceiling for the CL600-2B19 (RJ200). Data is provided in this document utilizing the following climb speed schedules:

Long Range Climb Speed – 250KIAS / 0.70 Mach
Normal Climb Speed – 250/290 KIAS / 0.74 Mach
High Speed Climb – 250/320 KIAS /0.77 Mach

Attachment 5-1 shows the climb schedule to be used during a “long range climb speed”, maximum climb thrust maneuver in an atmosphere of ISA +10 deg C. Note for all initial climb weights, a constant speed of Mach 0.7 is recommended above 33,000 feet

Attachment 5-2 shows the climb capability of the aircraft for several different initial weights using the long range climb speed. Note that for all weights, the rate of climb capability reduces as the altitude increases, particularly above 36,000 feet, when the aircraft should be operating at a constant Mach 0.7. However, at the accident aircraft weight, the aircraft would still have a positive rate of climb at 41,000 feet if at an airspeed of Mach 0.7. Attachments 5-3, 5-4, and 5-5 show the rate of climb limits up to the climb ceiling for climb rates of 100, 300 and 500 fpm, respectively. Note that 41,000 feet is within the Mach 0.7 envelope for an aircraft weight of 38,000 pounds, and ISA +10. However the 300 fpm climb ceiling at the same weight and temperature as the accident conditions is about 40,000 feet, and the climb ceiling at 500 fpm is about 38,700 feet.

Attachments 5-6 through 5-11 show the recommended altitude selection section from the Flight Planning and Cruise Control manual. The optimum altitude recommendation in this section ensures a maneuver load factor of 1.3g before buffet onset when operated at the recommended speeds. Optimum altitudes are shown in these charts for 0.74 Mach, 0. 77 Mach, and 0.80 Mach, and long range cruise speeds.

<u>Climb to 41,000 feet</u>

Engine and longitudinal parameters are shown in figures 5-7 and 5-8 during the climb from 34,000 feet to 41,000 feet. This part of the climb was performed with the autopilot engaged. While below 35,000 feet, the airplane was climbing at a vertical speed of 1000 feet per minute (fpm), as selected in the autopilot. The engines maintained an N1 setting of 95.5%, and Mach number varied slightly between 0.60 and 0.61. As the airplane passed through 35,000 feet, the autopilot vertical speed selection was reduced stepwise to zero, and the aircraft leveled off at 36,500 feet at 02:41:00. During this level off, the calculated Mach number began to increase.

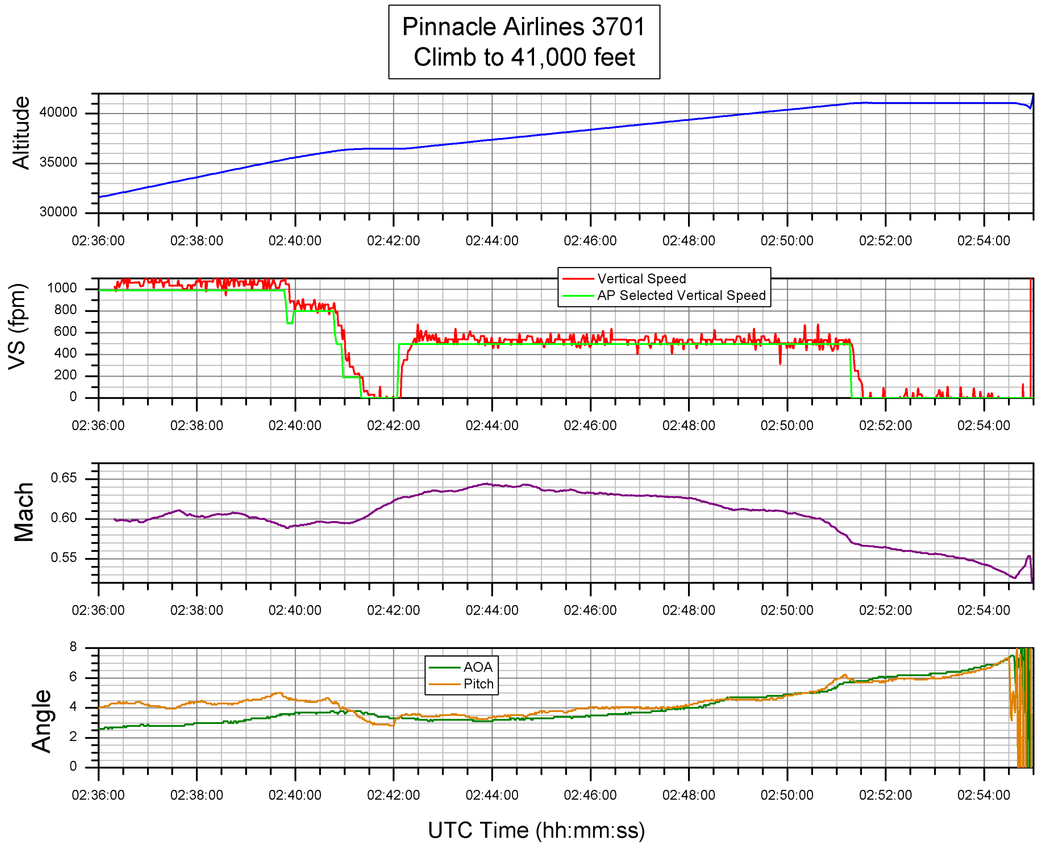


Figure 5-7

Shortly after 02:42:00, a vertical speed of 500 fpm was selected on the autopilot. The engines increased in N1 by about 0.5%, and Mach number continued to increase. By 02:44:00, the aircraft was passing through 37,400 feet and the Mach number reached 0.644. The airplane continued this climb at a vertical speed of 500 fpm over the next 7 minutes, until reaching the final altitude of 41,000 feet. During these 7 minutes, the calculated Mach number showed a continuous decay to 0.57. The pitch angle had increases from about 3 degrees to about 6 degrees, and N1 on both engines had reduced to 94.7%.

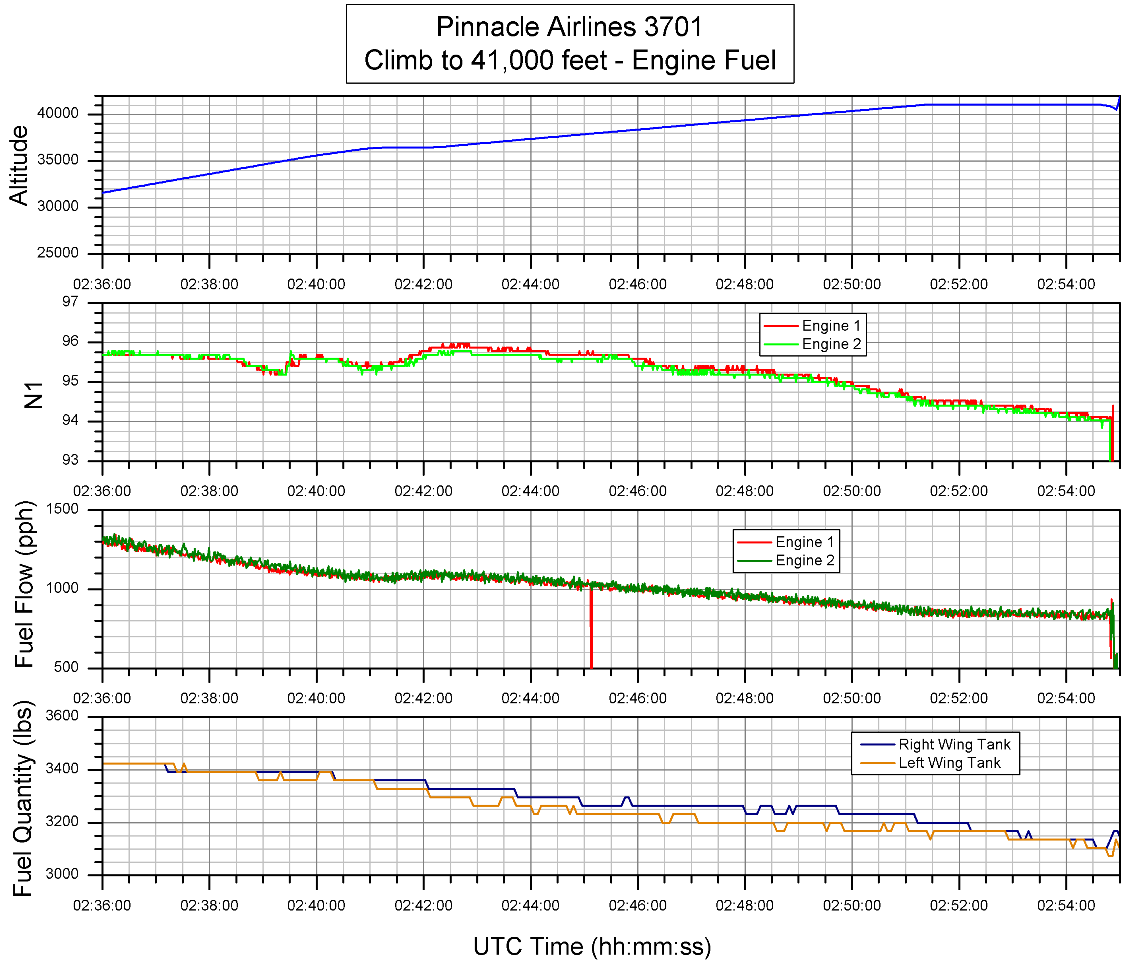


Figure 5-8

Once the airplane reached 41,000 feet, vertical speed reduced to zero as the selected altitude was captured by the autopilot, and the airplane leveled off. Over the next 3.5 minutes, calculated Mach number continued to decay to about 0.53, pitch angle and angle of attack continued to increase to close to 7 degrees, and N1 in both engines continued to reduce by another 0.5%.

Upset at 41,000 feet

Parameters detailing the upset at 41,000 feet are shown in figures 5-9 and 5-10. Engine parameters during the upset are displayed in figure 5-11. At 02:54:34, the airspeed had decayed to 150 knots (calculated Mach = 0.526). A single discrete for stick shaker on the right side switched to "on", and the autopilot disconnected. The control column moved to close to zero degrees by 02:54:35. 3.5 seconds after autopilot disconnect, a pull on the control column, calculated to be 25 pounds, occurred which was then released. Over the next few seconds, the control column moved again to 4 degrees in the airplane nose up direction, with airplane nose up column forces calculated to be up to 26 pounds. During this column movement, the pitch increased to close to 8.5 degrees.

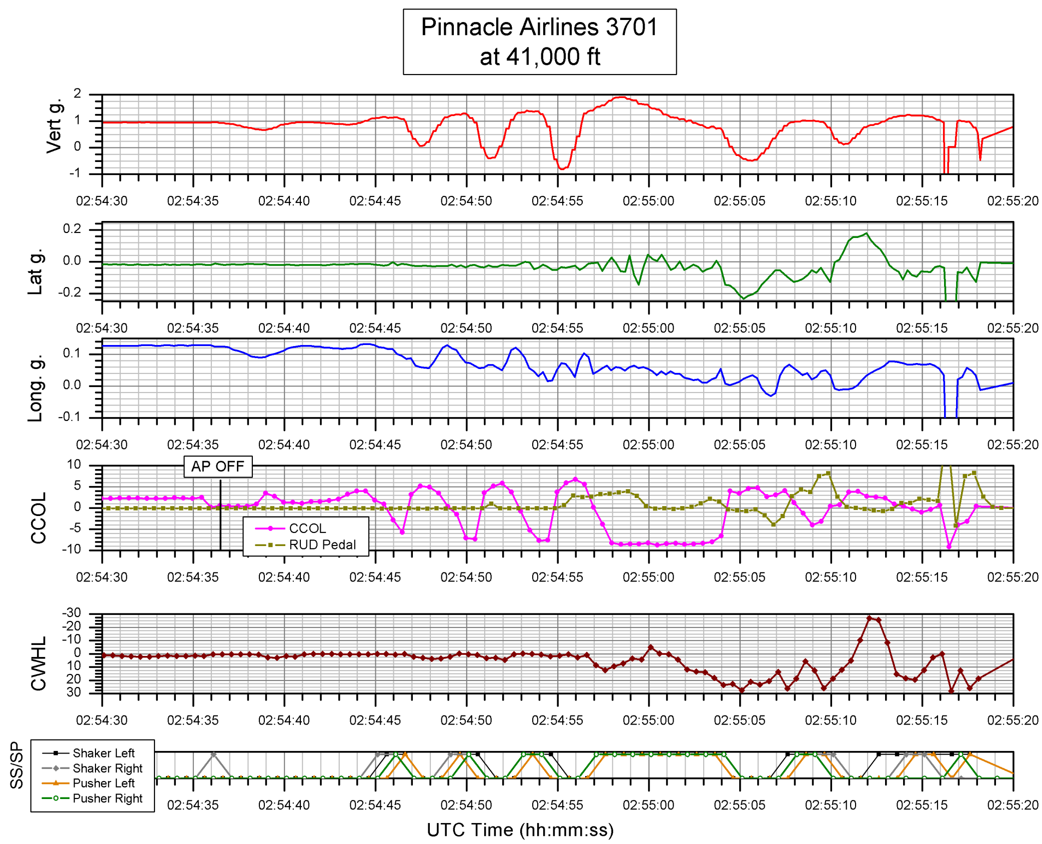


Figure 5-9

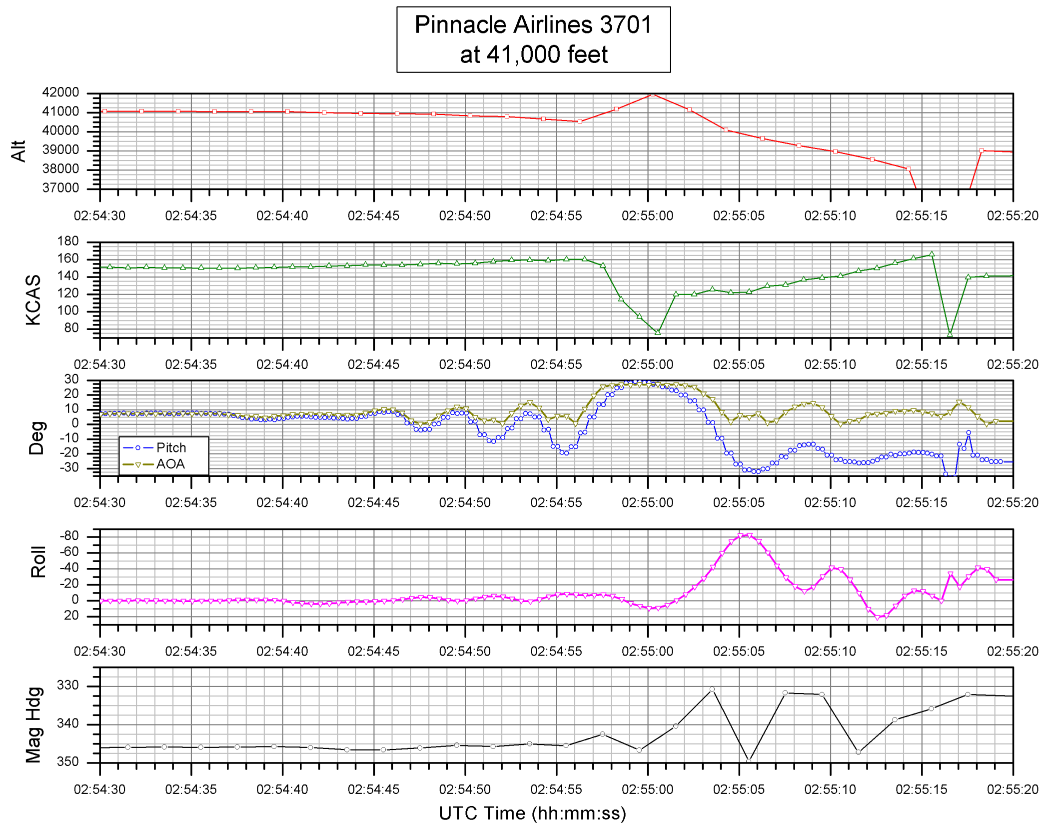

Pinnacle Airlines 3701
at 41,000 feet
Alt
KCAS
Deg
Pitch
AOA
Roll
Mag Hdg
UTC Time (hh:mm:ss)

Figure 5-10

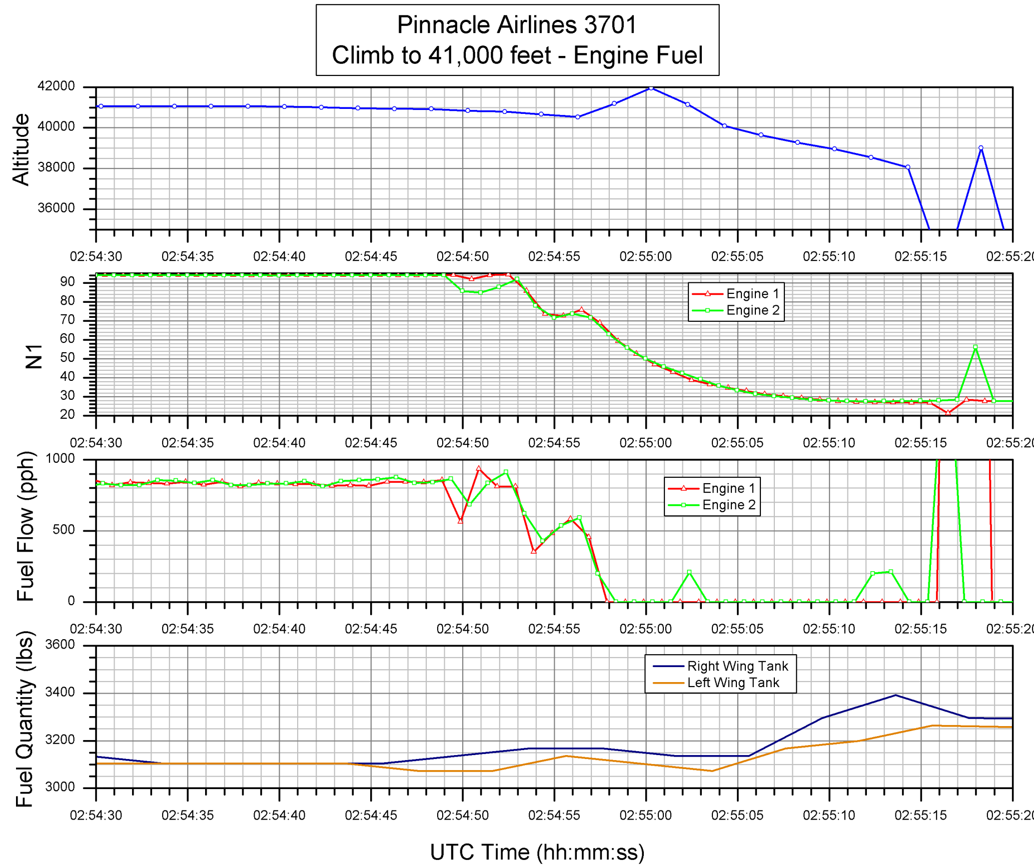


Figure 5-11

By 02:54:45, the angle of attack had increased sufficiently to activate both the stick shaker and stick pusher, and the column moved forward rapidly. Information from Bombardier Aerospace indicated that the stick pusher moves the column forward with a force of 80 pounds. The action of the pusher reduced the pitch angle to –3.5 degrees and the angle of attack to 0 degrees. The vertical acceleration reduced to near zero g's. As the vertical acceleration was reducing, the angle of attack reduced, the stick pusher cancelled, and the control column moved back beyond the neutral point to about 5 degrees airplane nose up. The aircraft pitched nose up to 8 degrees pitch angle and the angle of attack increased to 11 degrees, leading to another stick pusher activation.

Over the next 8 seconds, this same procedure is repeated two more times, with the stick pusher moving the column forward, and after pusher release from reduction of angle of attack, movement of the control column beyond the neutral point to airplane nose up. During the pitch up in the second of the cycles at 02:54:51, the first drop in engine 2 N1 is noted, from a steady value of 94%

down to 84%. After 02:54:53, both engines N1's and fuel flows begin to reduce in value.

These subsequent cycles cause the airplane nose down pitch angle in each pusher activation to increase, reaching –19.5 degrees by 02:54:55. The subsequent pull back on the control column went to a higher nose up value each cycle, reaching 6.8 degrees on the third pull at 02:54:56. The nose up movement also caused the vertical acceleration to reach lower values in each cycle, reaching a maximum of –0.8 g's. During these cycles the airspeed had increased to 160 knots.

By 02:54:57, the stick pusher had activated a fourth time, pushing the column to full nose down, where it remained for the next 4.5 seconds. During this push, the angle of attack reached the maximum measurable value of 27 degrees[3]. Engine fuel flow has reduced to near zero by 02:54:58. Pitch angle reached a maximum value of 29 degrees at 02:54:59. The recorded airspeed was only 74 knots at this time, and the altitude is increasing. However, according to Bombardier, the static source errors corrections programmed into the aircraft Air Data Computers (ADC) are not calibrated for the high angle of attack experienced at this time (> 27 degrees) and the recorded values of airspeed and altitude may not be accurate.

As the pitch angle began to reduce, a left rolling motion started, eventually reaching 82 degrees left wing down, and the pitch reached –32 degrees at 02:55:06. Over the next 14 seconds during the recovery from this upset, there is considerable control column, control wheel, and rudder movement. The stick pusher activated three more times during this recovery. Engine fuel flow remained near zero, and both engines N1 are exhibited decay in value. The FDR stopped recording data by about 02:55:20.

<u>Glide/Descent</u>

The FDR began recording data again at 02:59:16. When the FDR begins recording data again, the engines are no longer operating. Several attempts to re-start the engines were made over the course of the next 15 minutes. For details of the engine start attempts, see the Flight Data Recorder Group Chairman Factual Report, the Cockpit Voice Recorder Group Chairman Factual Report, and the Operations Group Chairman's Factual Report. Flight parameters during the descent are shown in figures 5-12 and 5-13.

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[3] The limit of 27 degrees angle of attack is the physical limit of the sensor. Physically higher angles of attack will be recorded as this limit

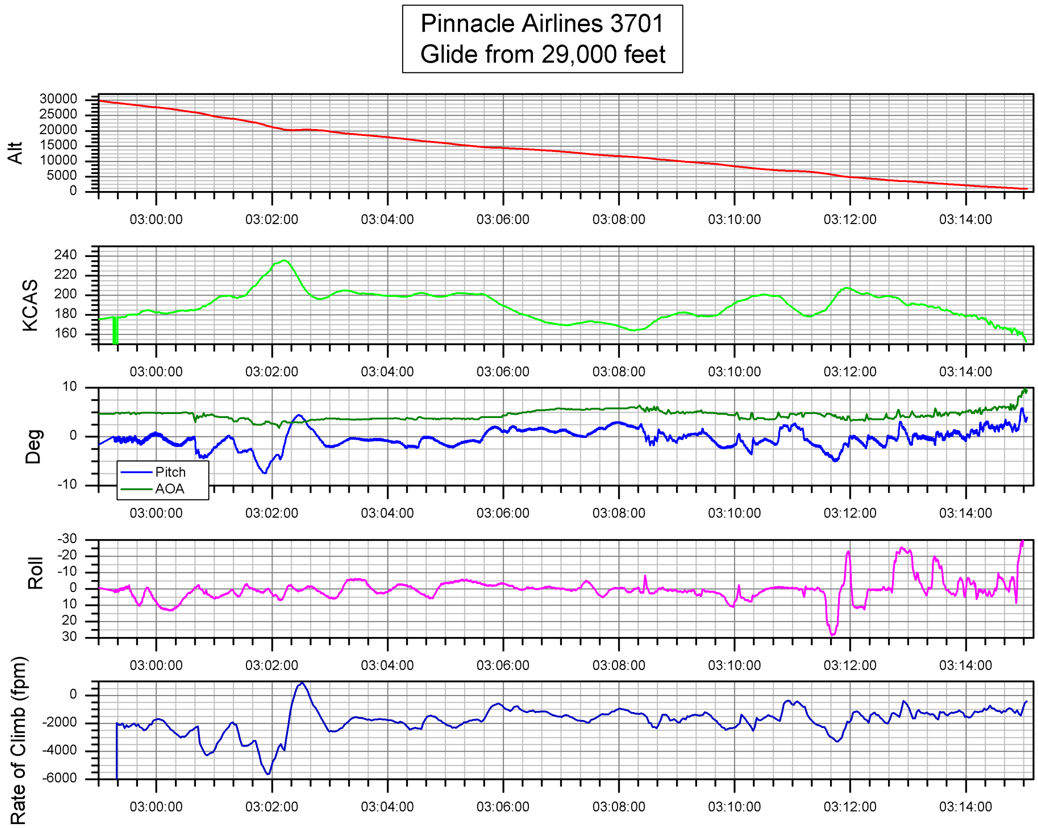
Pinnacle Airlines 3701
Glide from 29,000 feet
Alt
KCAS
Deg
Pitch
AOA
Roll
Rate of Climb (fpm)
03:00:00
03:02:00
03:04:00
03:06:00
03:08:00
03:10:00
03:12:00
03:14:00

Figure 5-12

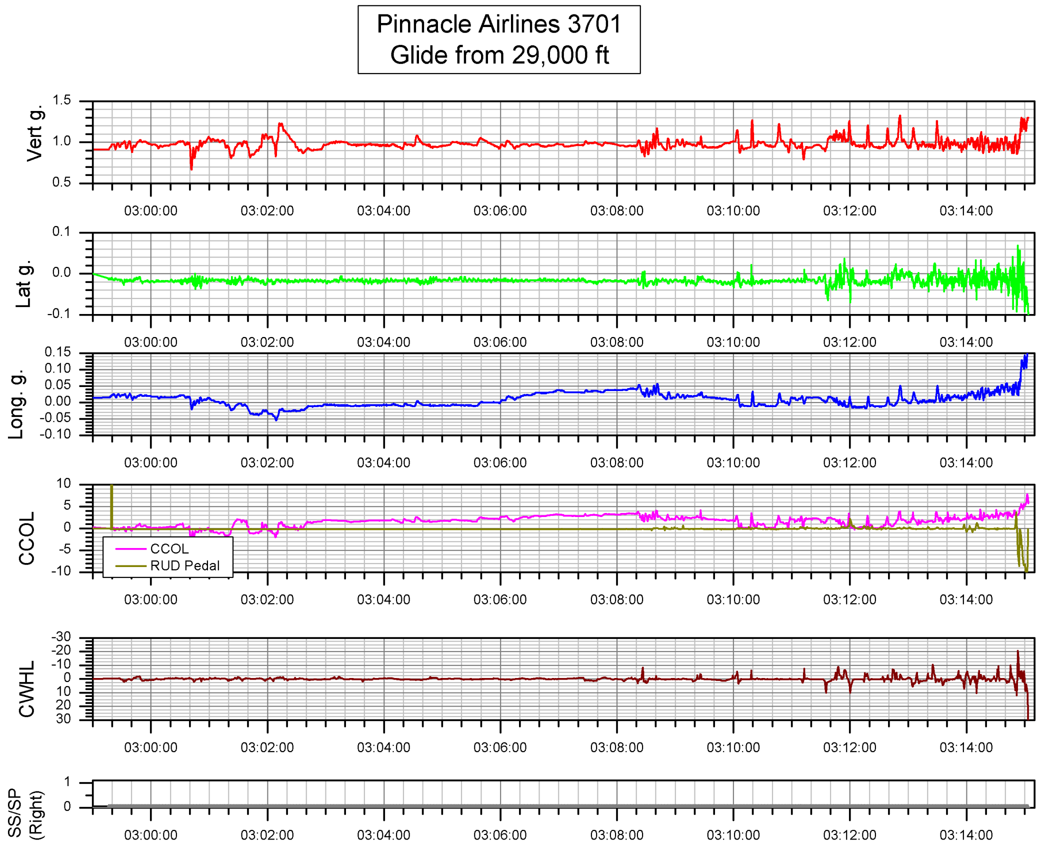

Figure 5-13

During the initial part of the descent, airspeed increases as the pitch of the airplane is reduced to close to 8 degrees. As the pitch remained nose down, the descent rate reached a maximum of -5000 fpm. A maximum airspeed of 236 knots is reached at 03:02:12, as the aircraft passed through 20,500 ft –msl altitude. The airplane is then leveled near 20,300 feet for the next 30 seconds. The aircraft then begins to descend again at rates between 1800 and 2000 fpm as the aircraft's speed is maintained at about 200 knots.

At about 03:04:46, the airspeed began to reduce as the pitch of the airplane increased while passing through 15000 feet altitude. The airspeed reduced to close to 170 knots, and varied slightly over the next several minutes. The descent rate then varied between 1000 and 2000 feet per minute.

At 03:09:06, while at an altitude of 10,000 feet, Flight 3701 notified ATC that they needed the closest airport available. Flight parameters from this point of the flight until the end of the FDR recording are shown in figures 5-14 and 5-15. Also plotted in figure 5-13 is the best glide airspeed of 170 knots for the estimated aircraft gross weight. During this portion of the glide, the airspeed varied between 180 and 206 knots., as the descent rate varied between 300 and 3200 feet per minute. Additionally during this part of the descent, several short pull backs on the control column occurred, along with concurrent variations of pitch angle and correlated increased of vertical accelerations up to as high as 1.3 g's.

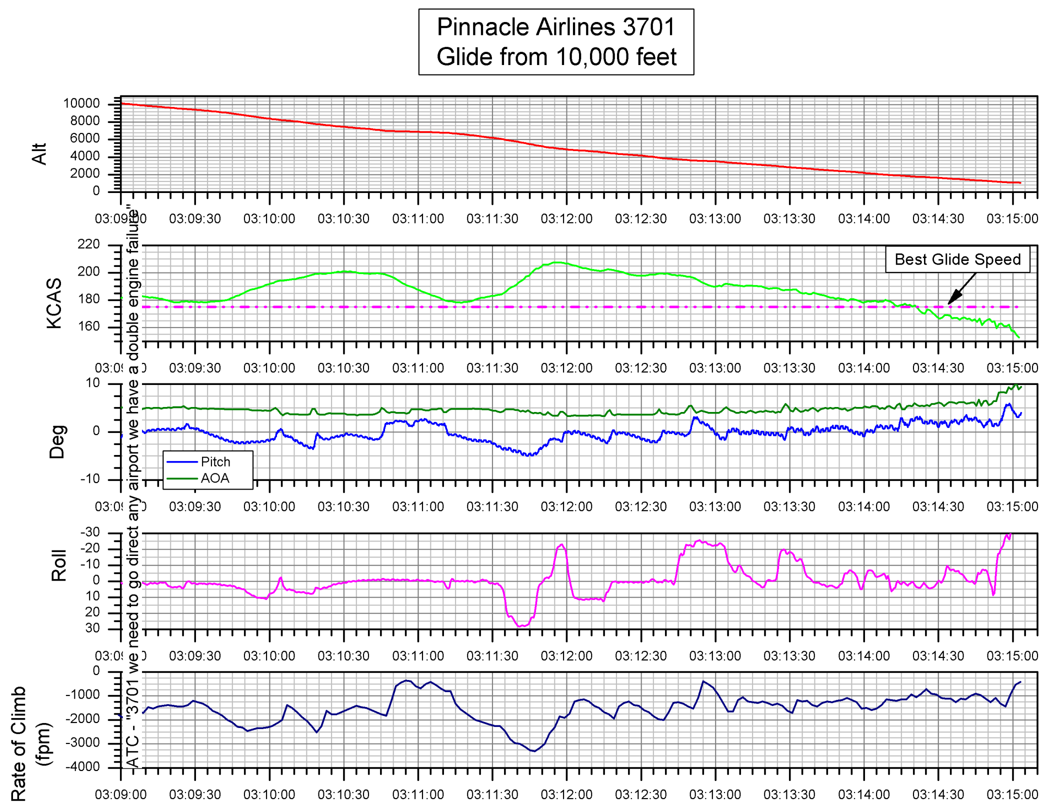

Figure 5-14

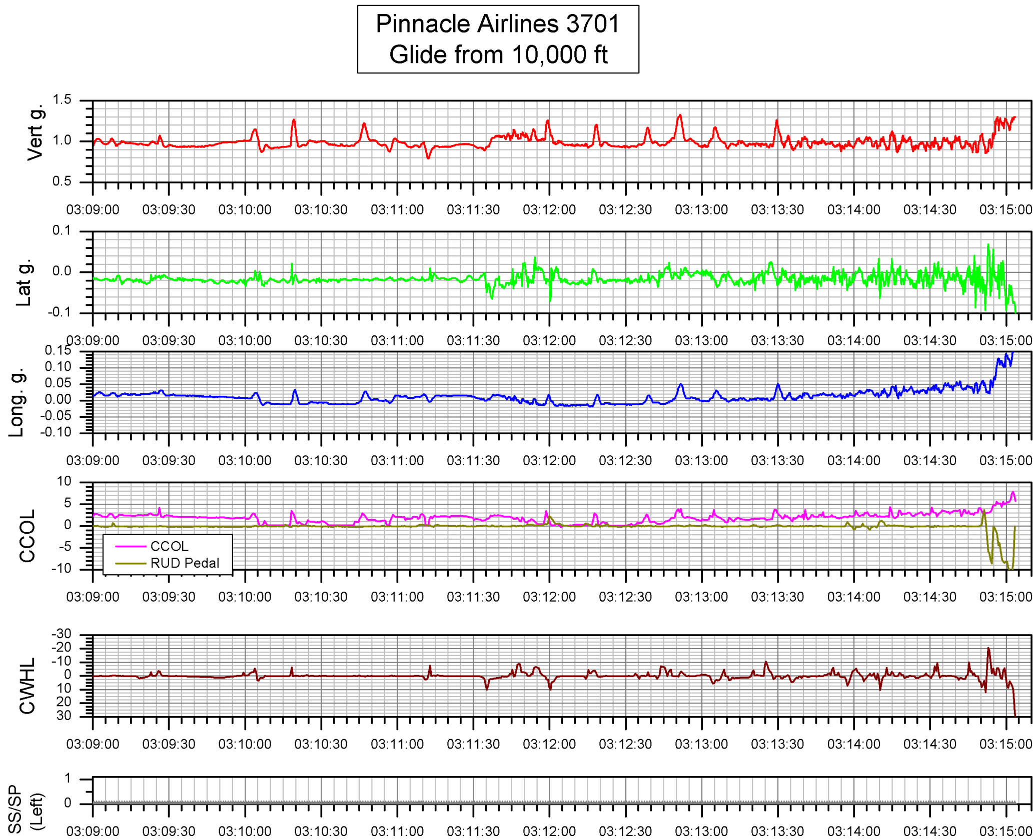

Figure 5-15

5. Glide Performance

Data was obtained from Bombardier Aerospace regarding the glide performance of the CRJ 200 at the accident weight. Data from the FDR also indicated that the flight spoilers were deployed to 5.6 degrees from 28,000 feet until the end of the recording. The additional drag from the flight spoilers and the air driven generator (ADG) was included to the glide performance calculations. The reference speed for the glide calculations was 170 knots. Table 5-1 below shows the data provided by Bombardier. The first column is the flight level that the all engine-out glide is started. Distances and times stated in this table are to reach sea level. The Jefferson City airport is located at an elevation of 549 feet, and with the altimeter setting or the day placed JEF at a pressure altitude of 819 feet. Hence, distances to reach JEF based on pressure altitude are displayed in the final column, are offset for increased elevation using a linear interpolation of the data between 2000 feet and sea level. Also shown for comparison to demonstrate the relative penalties of operating at airspeeds other than best glides are the distances to sea level at best glide speed -20 knots and best glide speed +20 knots

Table 5.1 All Engine Off Descent – Flight spoilers deployed, ADG Deployed

Flight altitude (100's ft)	**Glide time to sea level (min)**	**Glide distance to sea level (nm)**	**Glide distance to JEF on 10/14/04 (nm)**	**Increase in distance with spoilers retracted (nm)**	**Glide distance to sea level, Best glide speed - 20 knots (nm)**	**Glide distance to sea level Best glide speed + 20 knots (nm)**
200	12.36	48.85	46.94	2.76	49.55	46.33
180	11.4	43.64	41.73	2.46	44.35	41.32
160	10.39	38.53	36.63	2.16	39.22	36.41
140	9.33	33.5	31.60	1.87	34.15	31.61
120	8.2	28.54	26.64	1.59	29.14	26.89
100	7.0	23.65	21.75	1.31	24.18	22.25
80	5.74	18.82	16.92	1.04	19.26	17.68
60	4.42	14.04	12.14	0.78	14.39	13.18
40	3.02	9.32	7.42	0.51	9.56	8.73
20	1.55	4.64	2.74	0.25	4.76	4.34

Glide distances for the accident aircraft conditions were placed on the radar/map overlay and shown with several airport locations in figure 5-16. Glide footprints are shown for glides beginning at 30 thousand, 20 thousand, and 10 thousand feet, and reflect the glide distances available to reach a pressure altitude of 819 feet.

Daniel R. Bower
Senior Aerospace Engineer

Figure 5-16


DeLorme
Topo USA® 5.0
Glide range from 10,000 feet
Glide range from 20,000 feet
Glide range from 30,000 feet
10,000 feet
20,000 feet
30,000 feet
Start of upset (41,000 feet)
Jefferson City
JEF
Sedalia
Knob Noster
Windsor
Warsaw
Versailles
Eugene
Meta
Tuscumbia
Osage Beach
AIZ
Camdenton
Vienna
VIH
Linn
Hermann
Owensville
Belle
Bland
Steelville
Richland
Waynesville
TBN
Lebanon
LBO
Buffalo
Bolivar
Fair Play
Hermitage
Salem
Marshfield
Hartville
Houston
Willard
SGF
Springfield
Republic
Seymour
Mountain Grove
Cabool
Summersville
Eminence
Nixa
Ozark
Ava
Willow Springs
Mountain View
Galena
Forsyth
Hollister
Gainesville
West Plains
Alton
Mark Twain National Forest
Ft Leonard Wood Military Reservation
Gasconade River
Data use subject to license.
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www.delorme.com
MN (0.0° W)
0 6 12 18 24 30 mi
Data Zoom 7-5

Attachment 2-1

Tabular Radar Data

Attachment 2-1 Tabular Radar Data relative to Crocker Antenna

UTC hour	min	sec	Range (nm)	Azimuth (Deg)	Uncorrected Altitude (ft)	North (nm)	East (nm)	Latitude (N)	Longitude (W)
2	42	26.2	100.75	177.275	36500	-100.538	4.785	36.2915538	92.2573491
2	42	38.2	99.625	177.187	36600	-99.404	4.884	36.3104685	92.255287
2	42	50.3	98.5	177.187	36700	-98.277	4.829	36.3292624	92.2564036
2	43	2.3	97.375	177.187	36800	-97.150	4.774	36.3480573	92.2575208
2	43	14.4	96.25	177.099	36900	-96.015	4.866	36.3669734	92.2556004
2	43	26.3	95.125	177.099	37000	-94.888	4.808	36.385769	92.2567538
2	43	38.4	93.875	177.011	37200	-93.627	4.889	36.4067942	92.2550731
2	43	50.4	92.75	176.835	37300	-92.485	5.114	36.4258404	92.2504053
2	44	2.4	91.625	176.835	37400	-91.357	5.052	36.4446356	92.2516657
2	44	14.6	90.5	176.835	37500	-90.230	4.989	36.4634321	92.2529268
2	44	26.6	89.375	176.748	37600	-89.095	5.062	36.4823539	92.2513974
2	44	38.6	88.25	176.748	37700	-87.967	4.998	36.5011516	92.2526946
2	44	50.6	87.125	176.748	37800	-86.840	4.934	36.5199508	92.2539925
2	45	2.6	86	176.748	37900	-85.712	4.870	36.5387516	92.2552912
2	45	14.7	84.875	176.572	38000	-84.569	5.066	36.557802	92.2512254
2	45	26.8	83.75	176.572	38100	-83.441	4.998	36.5766028	92.2525959
2	45	38.8	82.625	176.484	38200	-82.306	5.057	36.5955309	92.2513552
2	45	50.8	81.5	176.396	38300	-81.170	5.112	36.6144607	92.250186
2	46	2.9	80.375	176.396	38400	-80.042	5.041	36.6332637	92.2516292
2	46	14.9	79.25	176.308	38500	-78.906	5.092	36.6521952	92.2505675
2	46	26.9	78.125	176.308	38600	-77.778	5.019	36.6710006	92.2520478
2	46	39	77	176.22	38700	-76.642	5.064	36.6899342	92.2510938
2	46	51.1	75.875	176.132	38800	-75.506	5.105	36.7088694	92.2502115
2	47	3.1	74.75	176.044	38900	-74.370	5.143	36.7278061	92.2494011
2	47	15.2	73.625	175.957	39000	-73.234	5.176	36.746743	92.2486889
2	47	27.2	72.5	175.957	39100	-72.105	5.096	36.7655533	92.2503147
2	47	39.2	71.375	175.781	39200	-70.961	5.235	36.7846245	92.2474266
2	47	51.3	70.375	175.693	39300	-69.949	5.268	36.8014806	92.2467111
2	48	3.3	69.25	175.693	39400	-68.820	5.183	36.8202934	92.2484462
2	48	15.4	68.125	175.693	39500	-67.691	5.098	36.8391095	92.2501825
2	48	27.4	67	175.517	39600	-66.547	5.217	36.858187	92.2476818
2	48	39.5	66	175.517	39700	-65.543	5.139	36.8749181	92.2492906
2	48	51.5	64.875	175.341	39800	-64.397	5.248	36.8940002	92.2469981
2	49	3.6	63.875	175.253	39900	-63.385	5.264	36.9108657	92.2466524
2	49	15.6	62.75	175.166	40000	-62.248	5.264	36.9298194	92.2466108
2	49	27.6	61.75	175.078	40100	-61.236	5.273	36.9466886	92.2463979
2	49	39.7	60.625	174.99	40200	-60.098	5.268	36.9656481	92.2464747
2	49	51.7	59.625	174.814	40300	-59.077	5.362	36.9826557	92.2445111
2	50	3.8	58.625	174.902	40400	-58.080	5.182	36.999265	92.2482332
2	50	15.9	57.5	174.902	40500	-56.950	5.081	37.0181028	92.2503019
2	50	27.9	56.5	174.902	40600	-55.945	4.991	37.0348562	92.2521426

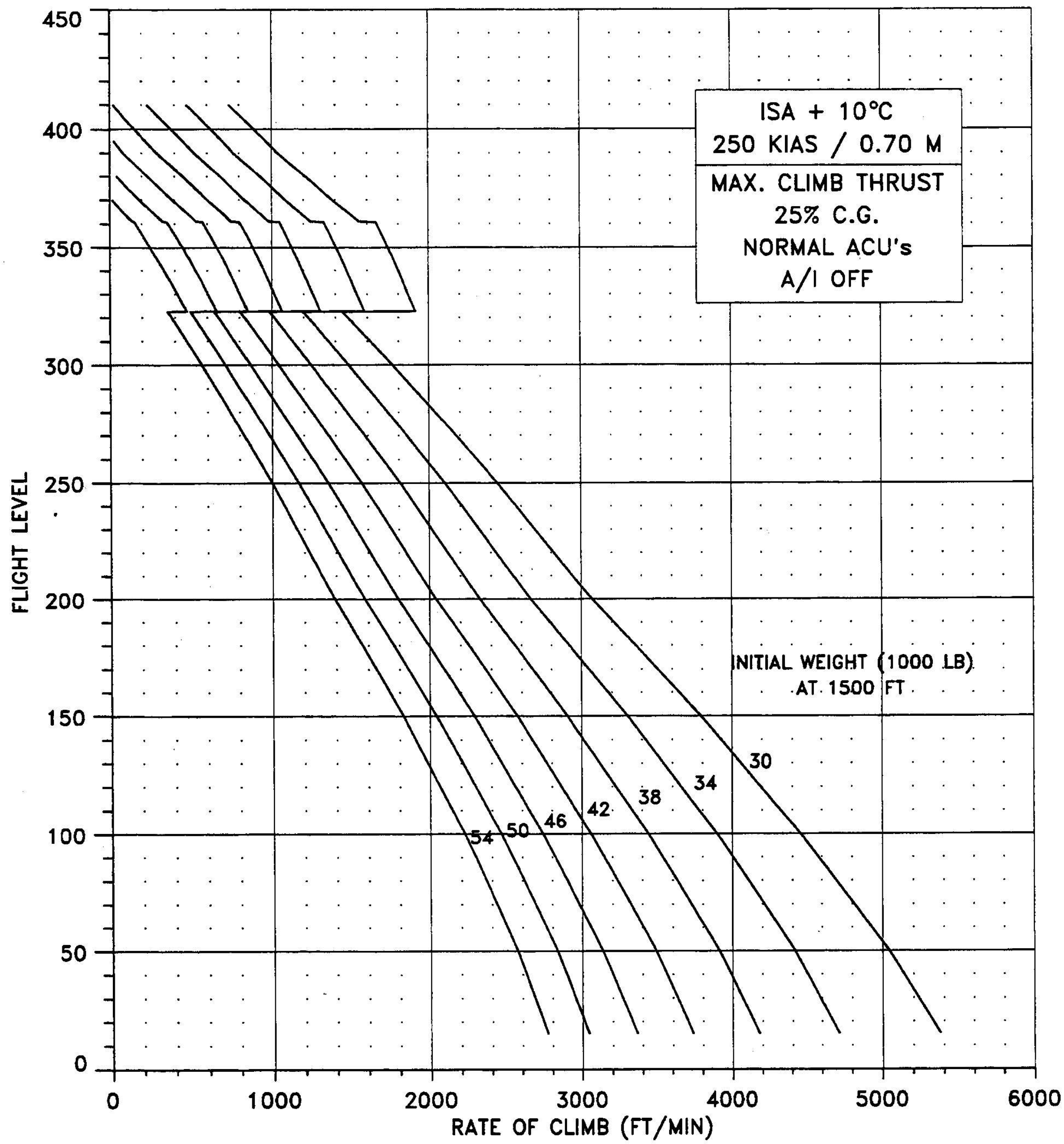
2	50	39.9	55.5	174.814	40700	-54.931	4.986	37.0517398	92.2522312
2	50	52	54.5	174.902	40800	-53.933	4.811	37.0683789	92.2558282
2	51	4	53.5	174.902	40900	-52.927	4.722	37.0851487	92.2576732
2	51	16	52.625	174.99	41000	-52.052	4.563	37.0997154	92.2609517
2	51	28.1	51.625	174.99	41000	-51.047	4.475	37.1164617	92.2627636
2	51	40.1	50.625	174.99	41000	-50.042	4.387	37.1332133	92.2645769
2	51	52.2	49.75	174.99	41000	-49.161	4.310	37.1478756	92.2661647
2	52	4.2	48.75	174.99	41000	-48.155	4.221	37.1646383	92.2679807
2	52	16.2	47.875	174.99	41000	-47.274	4.144	37.1793108	92.269571
2	52	28.2	46.875	175.078	41000	-46.273	3.985	37.1959841	92.2728695
2	52	40.2	45.875	175.078	41000	-45.266	3.898	37.2127686	92.2746581
2	52	52.3	45	175.166	41000	-44.390	3.754	37.2273654	92.2776445
2	53	4.4	44.125	175.166	41000	-43.507	3.679	37.2420664	92.2791842
2	53	16.4	43.125	175.166	41000	-42.498	3.594	37.2588758	92.2809454
2	53	28.5	42.25	175.166	41000	-41.614	3.519	37.2735917	92.2824879
2	53	40.5	41.375	175.166	41000	-40.730	3.445	37.2883153	92.2840318
2	53	52.6	40.375	175.166	41000	-39.720	3.359	37.3051523	92.2857982
2	54	4.6	39.5	175.253	41000	-38.840	3.225	37.3198125	92.2885752
2	54	16.6	38.625	175.253	41000	-37.954	3.152	37.3345657	92.2900961
2	54	28.7	37.75	175.341	41000	-37.072	3.021	37.3492516	92.2928065
2	54	40.7	36.875	175.341	41000	-36.185	2.949	37.3640276	92.2943027
2	54	52.7	36	175.341	40800	-35.303	2.877	37.37871	92.2957899
2	55	4.8	35.125	175.429	40300	-34.434	2.753	37.3931698	92.2983663
2	55	16.9	34.375	175.605	37600	-33.761	2.595	37.4043099	92.3016528
2	55	28.9	33.375	175.957	37600	-32.762	2.316	37.4209634	92.3074718
2	55	41	32.375	176.484	34300	-31.862	1.958	37.435875	92.3149331
2	55	53.1	31.25	176.835	34000	-30.740	1.700	37.4545557	92.3203113
2	56	5.2	30.375	177.275	34000	-29.863	1.421	37.4691651	92.326124
2	56	17.3	29.375	177.89	33600	-28.871	1.064	37.4856803	92.3335944
2	56	29.3	28.5	178.505	33400	-27.996	0.731	37.5002586	92.3405544
2	56	41.3	27.5	179.121	33100	-26.992	0.414	37.5169782	92.3471713
2	56	53.4	26.75	179.736	32900	-26.236	0.121	37.529572	92.3533044
2	57	5.5	25.875	180.351	32700	-25.349	-0.155	37.5443549	92.3590827
2	57	17.5	25.125	181.054	32500	-24.585	-0.452	37.5570787	92.3652992
2	57	29.7	24.25	181.845	32200	-23.691	-0.763	37.5719598	92.3718079
2	57	41.8	23.5	182.636	31800	-22.925	-1.055	37.5847205	92.3779304
2	57	53.8	22.875	183.339	31500	-22.281	-1.300	37.5954411	92.3830534
2	58	5.9	22.125	184.394	31200	-21.496	-1.652	37.6085053	92.3904279
2	58	18	21.375	185.097	30800	-20.722	-1.848	37.6214061	92.3945502
2	58	30.1	20.75	185.888	30500	-20.066	-2.069	37.6323267	92.3991885
2	58	42.3	20	187.294	30100	-19.258	-2.465	37.6457754	92.4074875
2	58	54.4	19.375	188.701	29800	-18.566	-2.841	37.6572949	92.4153851
2	59	6.4	18.75	189.843	29500	-17.882	-3.103	37.6686918	92.4208702
2	59	18.5	18.25	191.337	29200	-17.300	-3.469	37.6783766	92.4285523

2	59	30.7	17.625	192.832	28700	-16.594	-3.780	37.6901381	92.4350912
2	59	42.7	17.125	194.414	28300	-15.998	-4.112	37.700056	92.4420658
2	59	54.9	16.5	195.908	27800	-15.283	-4.356	37.7119633	92.4471995
3	0	7	15.875	197.402	27500	-14.557	-4.562	37.724056	92.4515506
3	0	18.6	15.125	198.544	27000	-13.744	-4.610	37.7375943	92.4525783
3	0	30.7	14.375	199.16	26400	-12.981	-4.510	37.7503075	92.4504953
3	0	42.7	13.625	199.775	25900	-12.215	-4.392	37.7630585	92.4480282
3	0	55.3	12.875	200.302	25100	-11.474	-4.245	37.7754038	92.4449636
3	1	7.4	12	200.917	24400	-10.601	-4.052	37.7899532	92.4409276
3	1	19	11.125	201.269	24000	-9.732	-3.788	37.8044462	92.4354075
3	1	31.1	10.25	201.533	23400	-8.878	-3.503	37.8186816	92.4294308
3	1	43.6	9.375	201.972	22700	-8.017	-3.235	37.8330183	92.4238107
3	1	55.2	8.375	202.5	21700	-7.045	-2.918	37.8492301	92.4171715
3	2	7.5	7.5	203.203	20800	-6.182	-2.650	37.8636038	92.4115531
3	2	19.5	6.5	203.554	20200	-5.175	-2.256	37.8803868	92.4032824
3	2	31.5	5.625	203.994	20300	-4.201	-1.870	37.896626	92.3951714
3	2	43.6	4.875	204.609	20300	-3.311	-1.517	37.9114627	92.3877455
3	2	56.2	4.25	205.927	20000	-2.524	-1.227	37.9245917	92.3816546
3	3	7.8	3.625	206.806	19500	-1.662	-0.840	37.9389567	92.3735112
3	4	2.1	3.25	15.82	17900	1.508	0.427	37.9918126	92.34683
3	4	14.2	3.625	17.05	17500	2.223	0.682	38.0037344	92.341466
3	4	25.8	4.25	16.787	17000	3.144	0.949	38.0190848	92.3358441
3	4	37.8	4.875	16.787	16600	3.929	1.185	38.0321736	92.3308482
3	4	49.9	5.625	17.314	16300	4.772	1.488	38.0462195	92.3244723
3	5	2	6.25	18.017	15900	5.442	1.770	38.0573898	92.3185121
3	5	14	7	18.281	15500	6.228	2.057	38.0704931	92.3124434
3	5	26.6	7.75	17.753	15100	7.025	2.249	38.0837823	92.3083906
3	5	38.2	8.5	17.138	14700	7.817	2.410	38.0969869	92.3049769
3	5	50.6	9.125	16.259	14500	8.483	2.474	38.1080998	92.3036255
3	6	2.2	9.875	15.468	14300	9.269	2.565	38.121203	92.3016974
3	6	14.2	10.5	14.765	14200	9.923	2.615	38.1321109	92.3006254
3	6	26.8	11.125	13.974	13900	10.588	2.635	38.1432006	92.3002049
3	6	38.9	11.75	13.359	13700	11.241	2.670	38.1540966	92.2994614
3	6	50.4	12.375	12.832	13500	11.891	2.708	38.1649232	92.2986312
3	7	2.4	13	12.216	13200	12.547	2.716	38.1758646	92.2984555
3	7	14.4	13.5	11.689	12900	13.074	2.705	38.1846666	92.2986887
3	7	26.5	14.125	11.162	12500	13.728	2.709	38.1955669	92.2985995
3	7	38.4	14.75	10.634	12200	14.379	2.700	38.2064236	92.2987802
3	7	50.9	15.375	10.107	11900	15.029	2.679	38.2172762	92.2992087
3	8	3	16	9.755	11700	15.670	2.694	38.2279569	92.2988843
3	8	15	16.625	9.58	11500	16.302	2.751	38.2384975	92.2976616
3	8	27	17.125	9.316	11200	16.815	2.758	38.2470692	92.297504
3	8	39	17.75	9.052	10800	17.455	2.781	38.2577329	92.2970223
3	8	51.1	18.375	8.876	10400	18.089	2.825	38.268319	92.2960791

3	9	3.1	19	8.701	10100	18.722	2.865	38.2788754	92.2952177
3	9	15.2	19.625	8.525	9800	19.354	2.901	38.2894306	92.2944461
3	9	27.3	20.25	8.261	9500	19.992	2.903	38.3000596	92.2944072
3	9	39.3	20.875	8.437	9200	20.606	3.056	38.3103052	92.2911418
3	9	51.4	21.5	8.437	8800	21.229	3.149	38.3207132	92.2891728
3	10	3.4	22.125	8.701	8300	21.838	3.342	38.3308751	92.2850706
3	10	15.5	22.875	9.14	7900	22.557	3.629	38.3428672	92.2789777
3	10	27.5	23.5	9.667	7500	23.143	3.942	38.3526391	92.2723377
3	10	39.6	24.125	10.371	7200	23.710	4.339	38.3621032	92.263914
3	10	51.7	24.75	10.81	6900	24.293	4.639	38.3718205	92.2575603
3	11	3.8	25.375	11.25	6800	24.871	4.947	38.381455	92.251008
3	11	15.8	26	11.689	6700	25.445	5.264	38.3910337	92.2442701
3	11	27.8	26.625	12.128	6300	26.018	5.591	38.4005857	92.2373292
3	11	39.9	27.25	12.568	5800	26.587	5.927	38.4100812	92.2301828
3	11	52	27.75	13.535	5200	26.972	6.493	38.4165024	92.2181784
3	12	4.2	28.375	14.501	4800	27.465	7.104	38.424726	92.2052105
3	12	16.3	28.875	15.468	4500	27.825	7.700	38.4307072	92.1925538
3	12	28.4	29.375	16.523	4200	28.158	8.353	38.4362623	92.1786799
3	12	40.4	29.875	17.578	3800	28.478	9.022	38.4415725	92.1644875
3	12	52.4	30.5	18.544	3600	28.914	9.699	38.4488413	92.1500896
3	13	4.5	31.125	18.896	3400	29.446	10.079	38.4577001	92.1420006
3	13	16.5	31.75	18.984	3100	30.022	10.328	38.4673065	92.1366921
3	13	28.5	32.375	18.896	2900	30.629	10.484	38.4774387	92.1333406
3	13	40.6	32.875	18.72	2600	31.135	10.551	38.4858836	92.1319012
3	13	52.7	33.375	18.369	2300	31.674	10.518	38.4948812	92.1325768
3	14	4.8	34	18.017	2100	32.333	10.516	38.5058717	92.1325714
3	14	16.8	34.5	17.666	1800	32.873	10.470	38.5148955	92.1335279
3	14	28.7	35	17.402	1600	33.398	10.468	38.5236598	92.1335421
3	14	40.7	35.5	17.138	1400	33.924	10.461	38.5324349	92.1336547
3	14	52.8	36	16.699	1200	34.482	10.344	38.5417544	92.1361002

Attachments 5-1 through 5-5

Climb Charts from Flight Planning and Cruise Control Manual



Rate of Climb (250 KIAS / 0.70 M), ISA + 10 °C
Figure 03-03-4

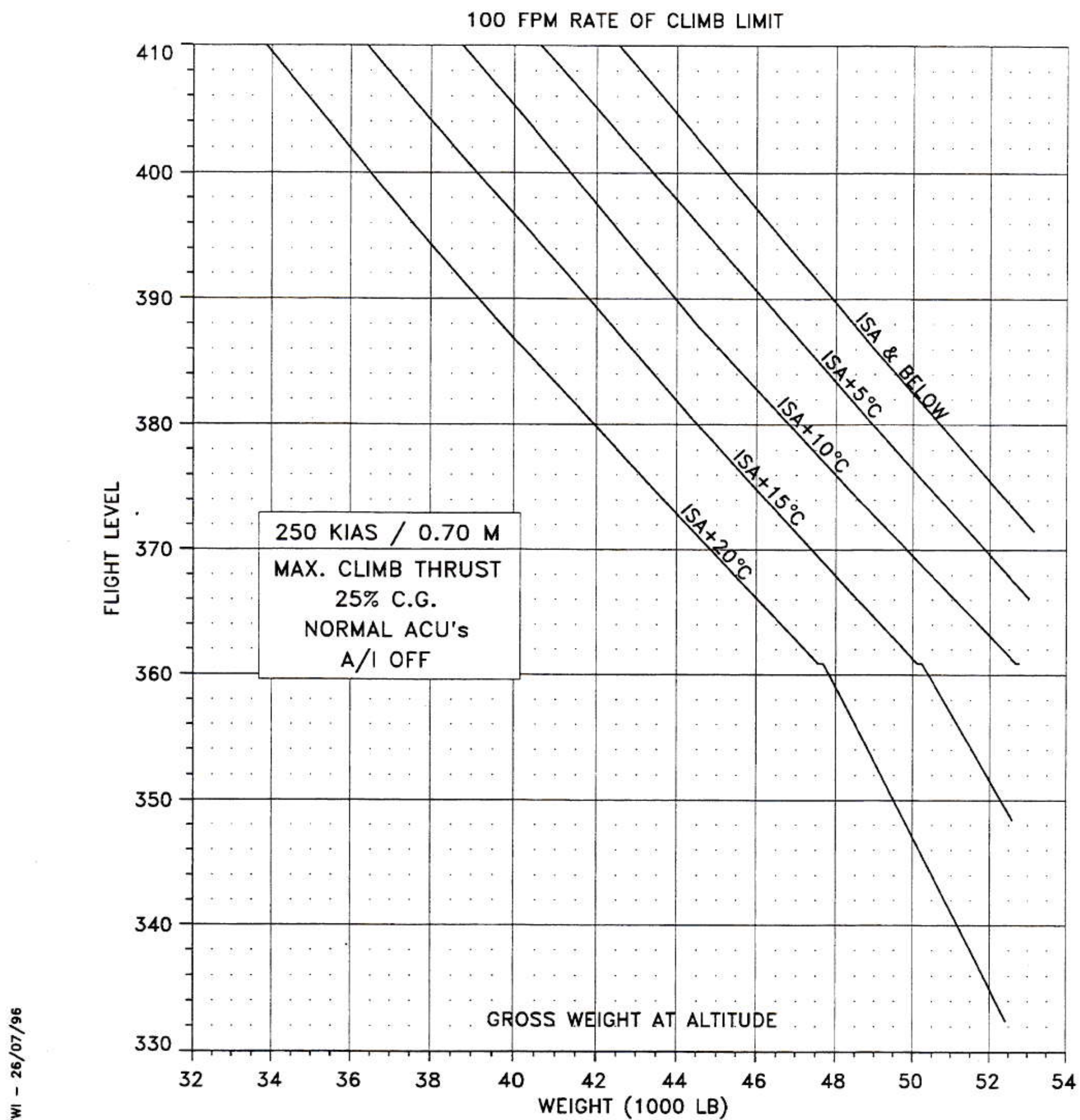
CLIMB 250 KIAS / 0.70 M

MAX. CLIMB THRUST NORMAL ACU'S A/I OFF	ISA + 10 C 25% C.G.	FROM 1500 FT	
		TIME (MIN)	FUEL (LB)
		DIST (NAM)	ATAS (KTS)
		MACH	ROC (FPM)

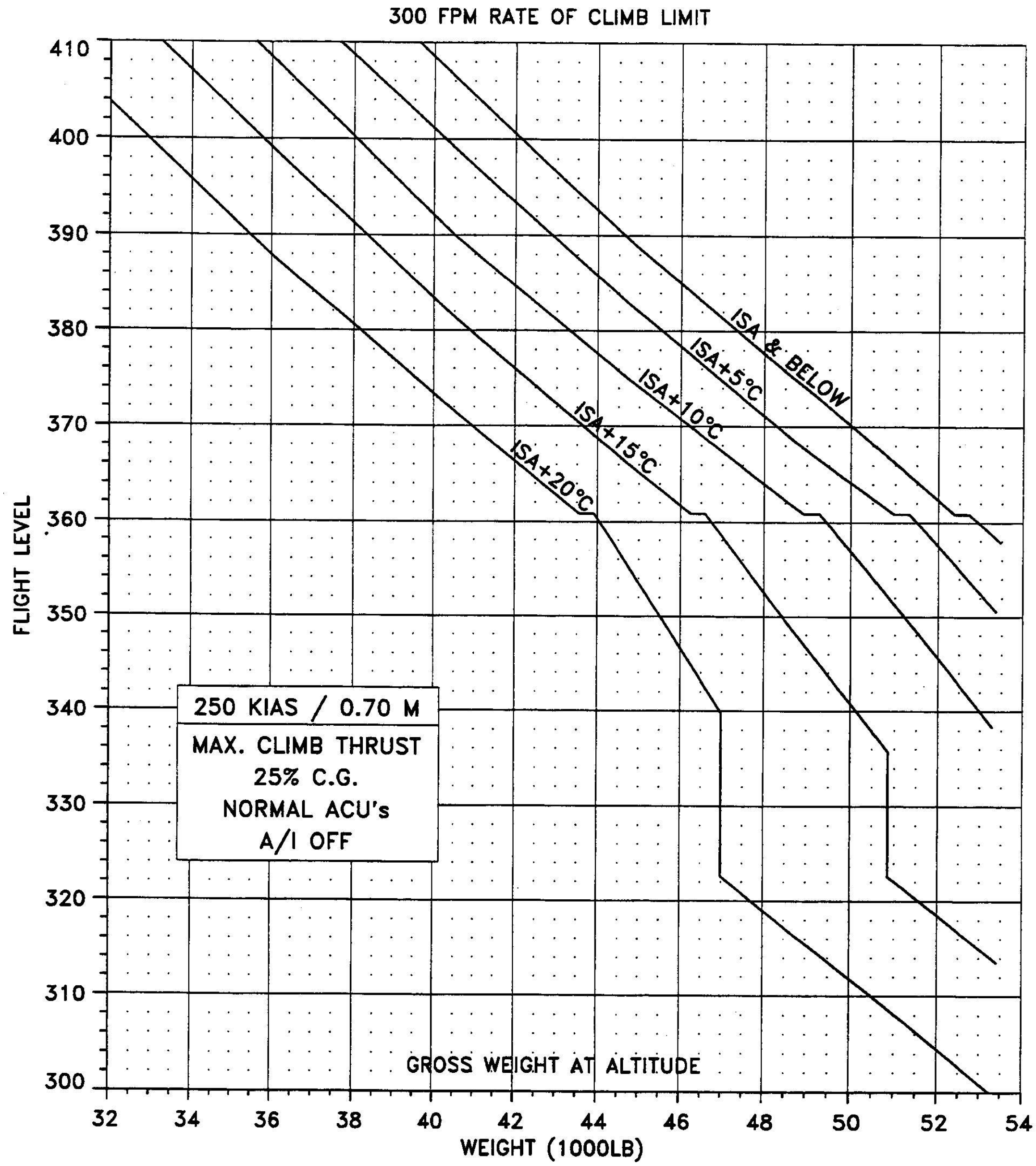
FLIGHT LEVEL	INITIAL CLIMB WEIGHT - 1000 LB											
	32		34		36		38		40		42	
410	19.3	995	21.4	1092	24.0	1207	27.4	1349	32.6	1554	45.4	2001
	120.0	374	133.7	375	150.6	377	173.0	379	208.1	383	294.8	389
	.700	605	.700	477	.700	354	.700	235	.700	121	.700	24
390	16.5	904	18.0	982	19.7	1068	21.6	1164	23.9	1274	26.7	1405
	100.7	367	110.4	368	121.2	370	133.6	371	148.4	372	166.8	374
	.700	896	.700	765	.700	642	.700	523	.700	407	.700	295
370	14.5	833	15.7	901	17.0	974	18.5	1053	20.1	1139	21.9	1234
	87.2	361	94.8	362	103.1	363	112.3	364	122.4	365	133.9	366
	.700	1228	.700	1088	.700	956	.700	834	.700	718	.700	605
350	13.0	775	14.1	836	15.2	900	16.4	970	17.7	1044	19.2	1125
	77.1	356	83.5	357	90.4	357	97.9	358	106.1	359	115.0	360
	.700	1564	.700	1406	.700	1261	.700	1126	.700	1002	.700	884
330	11.7	720	12.6	775	13.6	833	14.6	895	15.8	961	17.0	1031
	68.2	349	73.7	350	79.5	351	85.8	351	92.5	352	99.8	353
	.700	1694	.700	1537	.700	1391	.700	1257	.700	1132	.700	1016
310	10.3	656	11.1	705	11.9	756	12.8	810	13.7	867	14.7	927
	58.6	341	63.1	341	67.9	342	73.0	342	78.4	343	84.2	343
	.682	1486	.682	1359	.682	1241	.682	1133	.682	1033	.682	939
290	9.0	594	9.7	637	10.4	682	11.1	729	11.9	778	12.7	830
	49.9	332	53.7	332	57.6	333	61.8	333	66.1	334	70.7	334
	.655	1748	.655	1608	.655	1478	.655	1359	.655	1248	.655	1147
270	7.9	537	8.5	575	9.1	615	9.7	657	10.3	700	11.0	745
	42.7	324	45.9	324	49.1	325	52.5	325	56.1	325	59.9	326
	.628	2009	.628	1857	.628	1717	.628	1587	.628	1467	.628	1357
250	6.9	485	7.4	519	7.9	554	8.5	591	9.0	629	9.6	669
	36.6	317	39.2	317	42.0	317	44.8	318	47.8	318	50.9	318
	.604	2266	.604	2101	.604	1950	.604	1811	.604	1683	.604	1565
200	4.9	367	5.2	392	5.6	418	5.9	445	6.3	472	6.7	501
	24.5	300	26.2	300	28.0	301	29.8	301	31.7	301	33.6	301
	.547	2859	.547	2665	.547	2488	.547	2326	.547	2178	.547	2041
150	3.3	261	3.5	278	3.7	296	3.9	315	4.2	334	4.4	354
	15.5	286	16.6	286	17.7	286	18.9	287	20.0	287	21.2	287
	.497	3536	.497	3306	.497	3097	.497	2907	.497	2733	.497	2573
100	1.9	162	2.0	172	2.2	184	2.3	195	2.4	207	2.6	218
	8.7	273	9.3	274	9.9	274	10.5	274	11.2	275	11.8	275
	.452	4164	.452	3899	.452	3660	.452	3443	.452	3245	.452	3063
50	0.7	66	0.8	71	0.8	75	0.9	80	0.9	84	1.0	89
	3.3	262	3.5	263	3.7	263	3.9	263	4.2	264	4.4	264
	.413	4713	.413	4418	.413	4152	.413	3912	.413	3692	.413	3492

CLB25011I_3B - 22/03/96

Climb Performance (Climb Speed Schedule 250 KIAS / 0.70 M), ISA+10 °C (Page 1 of 2)
Figure 03-05-4

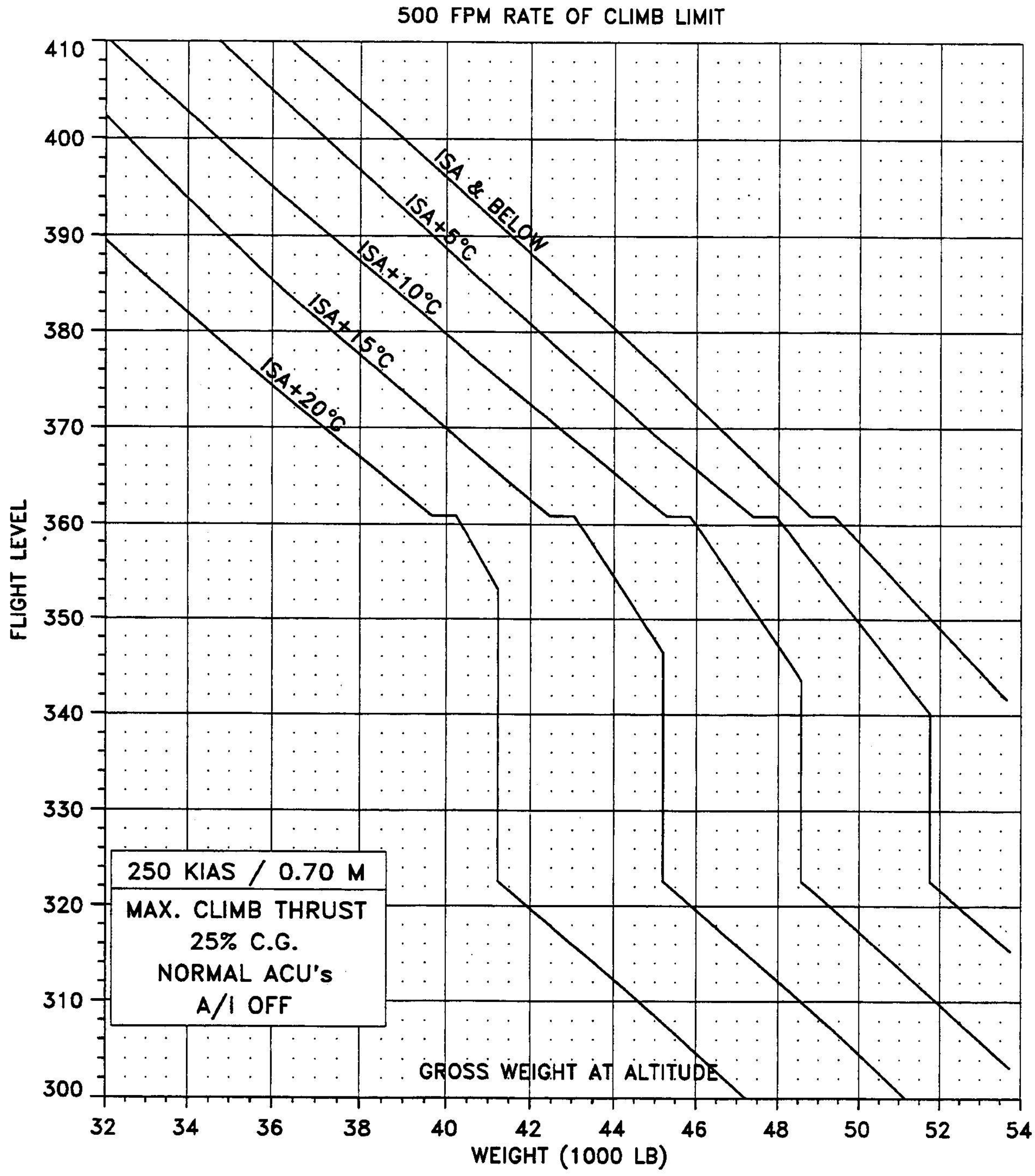


Climb Ceiling (Gross Weight at Altitude) – 250 KIAS / 0.70 M (100 FPM Rate of Climb Limit)
Figure 04–06–2



CLB250_300FPMALTWI - 31/07/96

Climb Ceiling (Gross Weight at Altitude) – 250 KIAS / 0.70 M (300 FPM Rate of Climb Limit)
Figure 04-06-4



CLB250_500FPMALTWI - 31/07/96

Climb Ceiling (Gross Weight at Altitude) – 250 KIAS / 0.70 M (500 FPM Rate of Climb Limit)
Figure 04-06-6

Attachments 5-6 through 5-11

Altitude Selection Charts from Flight Planning and Cruise Control Manual

1. INTRODUCTION

Cruise altitudes are presented for short and long trip distances.

A. Short Distances

Cruise altitudes are tabulated based on fixed take-off weights for stage lengths between 50 to 275 nautical miles. For short range operation, the cruise altitude is generally limited by the total distance covered by the airplane in climb and descent. Minimum cruise distance is 10% of the stage length. Long range cruise (LRC) and ISA temperature have been assumed for reasons of simplicity and to allow alternate route planning with minimum fuel burn.

B. Long Distances

Cruise altitude selection is governed by either 300 fpm ceiling limit altitude (see Climb Capability, section 03–04) or maximum altitude (optimum) with maximum cruise thrust. The optimum altitude shown here is the maximum attainable altitude with maximum cruise thrust and does not include the climb ceiling limitation. Recommended cruise altitude ensures a maneuver load factor of 1.3 'g' before buffet onset. Optimum cruise altitudes are given for 0.74 M, 0.77 M, 0.80 M and LRC cruise speeds for −10, 0, 5, 10, 15 and 20 °C temperature deviations from ISA.

Best fuel mileage for a given cruise speed is achieved at optimum altitude. A correction table gives fuel mileage penalty for operation at off-optimum altitudes for fixed Mach and LRC cruise speeds.

Normal air-conditioning on and anti-ice off conditions are assumed.

LRC is the speed for which the specific range is 99% of the maximum specific range at a given airplane gross weight and altitude combination.

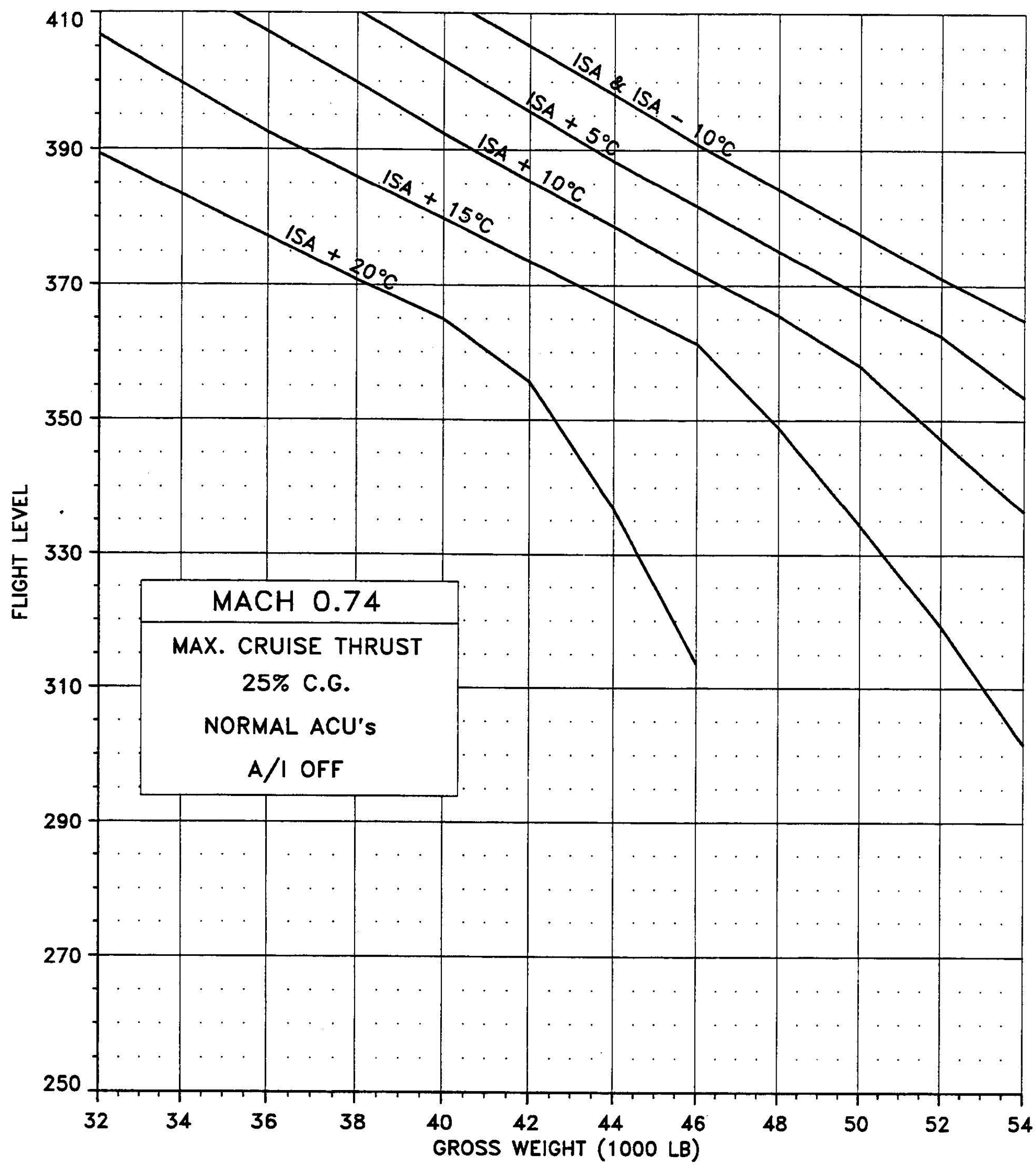
ALTITUDE SELECTION (SHORT DISTANCE)		
NORMAL ACU'S	ISA	LRC
A/I OFF	25% C.G.	RECOMMENDED FLIGHT LEVEL

TOW (1000 LB)	TRIP DISTANCE - NAM									
	50	75	100	125	150	175	200	225	250	275
34	140	200	250	290	310	350	370	390	410	410
36	140	190	240	280	310	330	370	390	410	410
38	130	180	230	270	290	330	350	370	390	410
40	130	180	220	260	290	310	350	370	390	390
42	120	170	210	250	270	310	330	350	370	390
44	120	170	210	250	270	300	330	350	370	370
46	120	160	200	240	270	300	310	330	350	370
48										370

SHORTLRCI_3B - 03/04/96

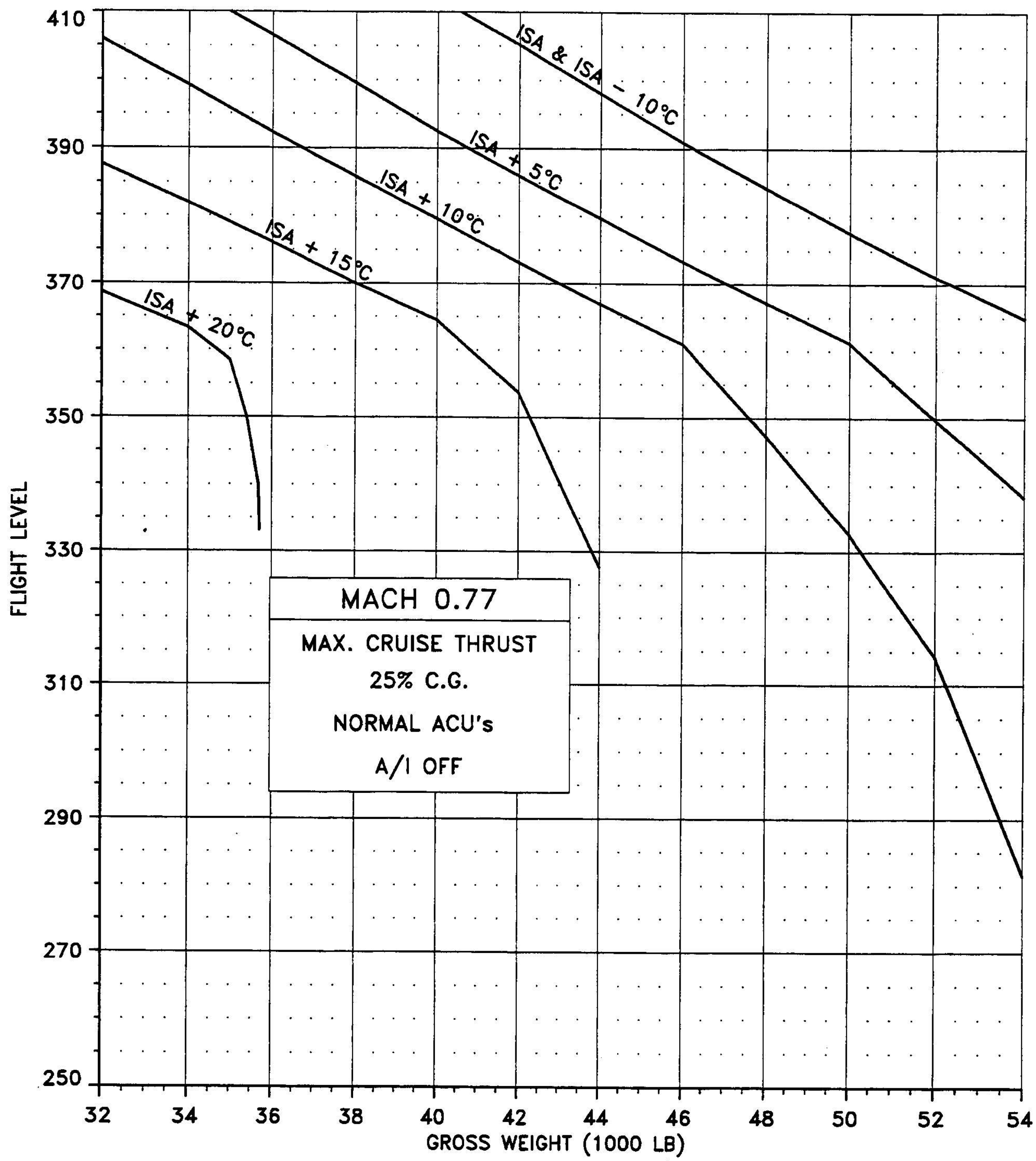
NOTES: - MINIMUM CRUISE DISTANCE, 10% OF TRIP DISTANCE
- VARIABLE PAYLOAD
- MZFW =44000 LB LIMIT WEIGHT

Altitude Selection (Short Distance)
Figure 03–04–1



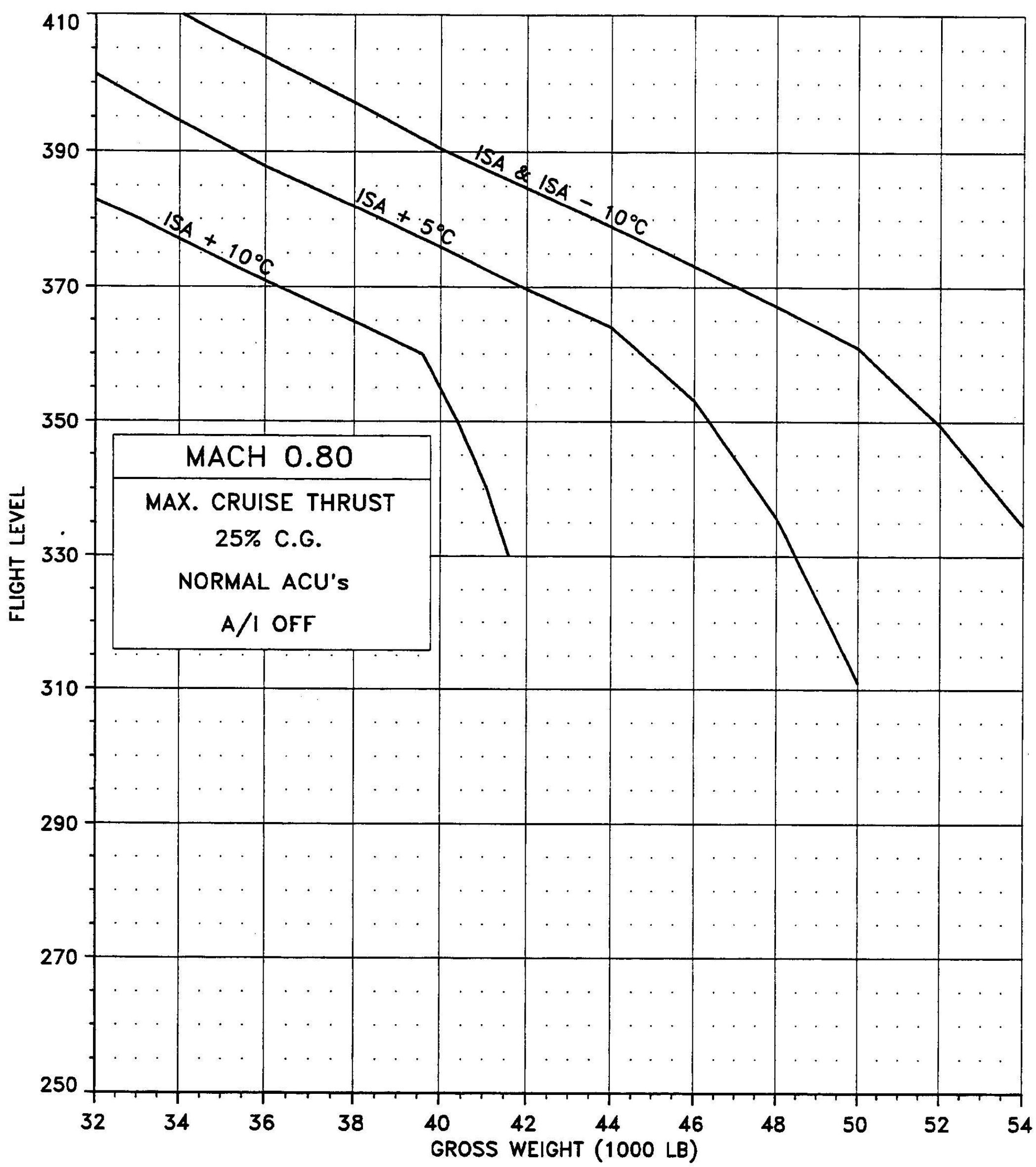
LONG74L_38 – 02/05/96

Altitude Selection (Long Distance) – 0.74 M
Figure 03–04–2



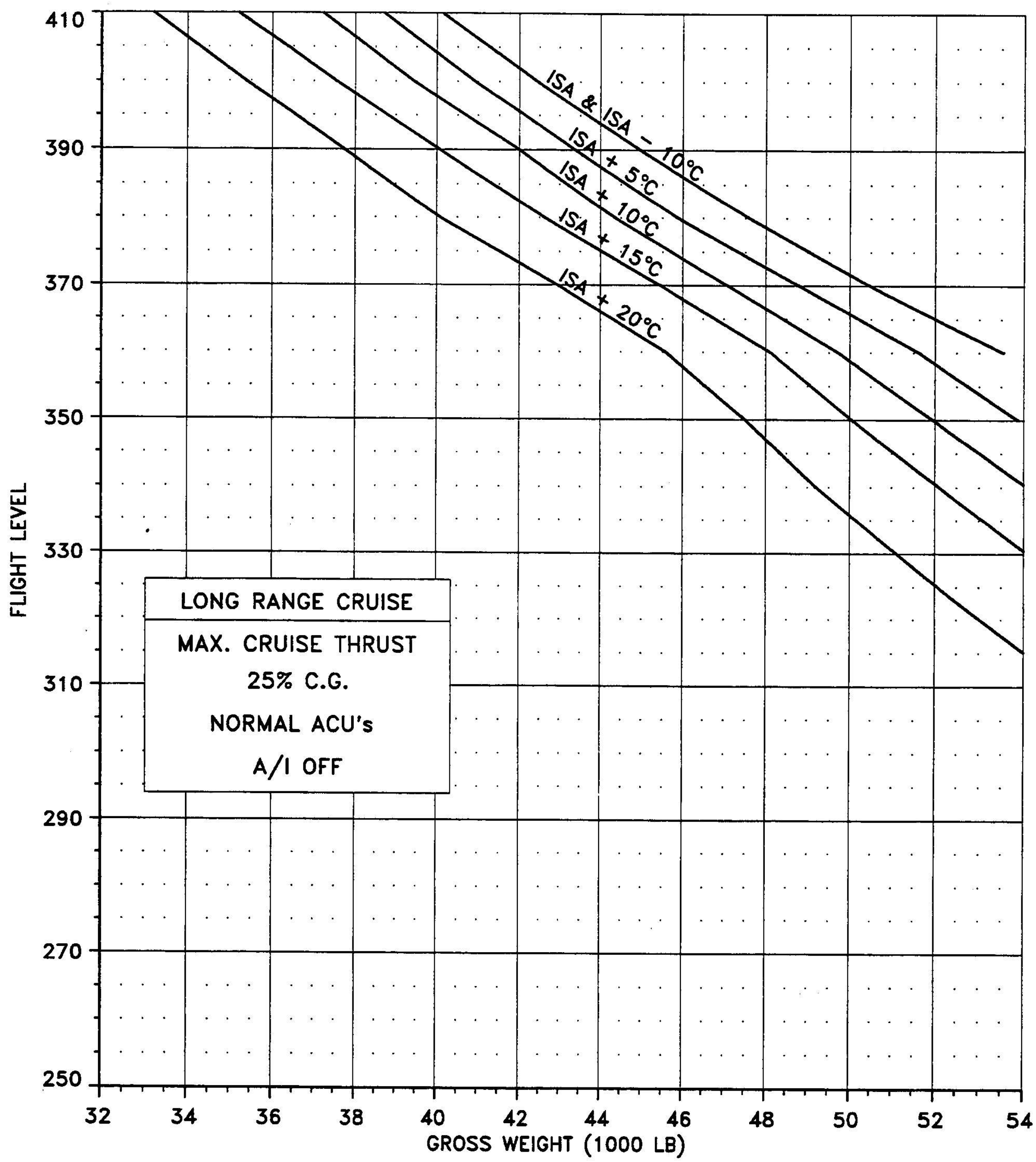
LONG77I_3B - 02/05/96

Altitude Selection (Long Distance) – 0.77 M
Figure 03–04–3



LONG801_3B - 02/05/96

Altitude Selection (Long Distance) – 0.80 M
Figure 03–04–4



LONGLRI_38 – 02/05/96

Altitude Selection (Long Distance) – Long Range Cruise
Figure 03-04-5